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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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SCHOOL SCIENCE AND MATHEMATICS

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A NEW EDITOR FOR THE PROBLEM DEPARTMENT.

With this issue Professor C. N. Mills has completed a term of six years as Editor of our Problem Department. Other work demands his attention. He has conducted this department very successfully and we give him our sincere thanks and earnest wishes for continued success as a teacher, writer and investigator.

While regretting the loss of Professor Mills we are pleased to announce that the Problem Department will be continued under the editorship of Professor G. H. Jamison, Head of the Mathematics Department of the Northeast Missouri State Teachers College, Kirksville, Mo. Professor Jamison is well fitted both by educational training and teaching experience for this work. He is a graduate of the University of Chicago, Mathematics Department, holds a Master Degree from the same school, and has completed more than an additional year of graduate work. His teaching experience includes several years in high school, a year in the Mathematics department of Oklahoma A. and M. College, and since 1912 he has been a member of the faculty of the Kirksville school. For the past six years he has been head of the Mathematics Department. This has given him an unusual opportunity to learn the needs and interests of teachers and students. The high standard and efficiency of our Problem Department will continue.

MORE NEWS FROM OUR EDITORS.

Dr. Duane Roller, Editor for Research in Physics, has had a busy year. His recent publications include (1)

"Effect of Temperature on the Photo-electric Behavior of Solid and Liquid Mercury" Physical Review, 36, 738 (1930); (2) Four articles in the Proceedings of the Oklahoma Academy of Science; (3) "Physical Terminology" Scientific Monthly, 31, 543 (1930). He is now engaged in investigating (1) Photoelectric Properties of Thin Films of Mercury, (2) Relative Optical Reflectivities of Solid and Liquid Mercury, (3) Optimum Operating Conditions for Light Sources Used in Photoelectric Work.

Mr. Joel W. Hadley is one of Indiana's most conscientious teachers. Boys and girls are his chief interest. In addition to the regular day at Shortridge he is the examiner for several Boy Scout Merit Badges and gives frequent lectures on birds. During the summer Mr. Hadley is a regular member of the faculty of the Nature Guide School of Western Reserve University where he has charge of the study of birds and insects.

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

American boys and girls have a wonderful heritage of forests, flowers, fertile soil, minerals, beautiful scenery, etc., but they have not been taught to enjoy it and save it for future Americans. Greed and carelessness have already destroyed much that can never be replaced. In order to do our bit in promoting respect for our great natural resources and preservation of them, a Committee on Conservation has been formed and is operating under the leadership of Mr. Fred Schriever, Boys' Technical High School, Milwaukee. This committee is making a systematic study of the teaching of conservation in the schools and has a program of constructive work well under way.

Our Secretary reports the third important gift to the Association this year. An active member and past president who has contributed much to the teaching of science and mathematics recently sent to the secretary the following letter:

Dear Mr. Roecker:

I enclose my $200.00 debenture for which I accept $150.00, donating the other $50.00 to the Central Association of Science and Mathematics Teachers. I am glad I can do this much for the Association.

FROM OUR FRIENDS IN OTHER LANDS.

On another page of this issue will be found some physics questions used in the secondary schools of France. These were contributed by Professor M. Ginat, Havre, France. His letter shows the progress of the testing movement in France, and the questions should give American pupils in physics an opportunity to compare their work with French students.

Another friend across the Atlantic is Mr. F. W. Turner, M. A., M. Sc., Alperton, Middlesex, England. Mr. Turner, as the Bush Research Fellow in Education, spent five months in America investigating the teaching of General Science for the English Board of Education. Mr. Turner reports that he found SCHOOL SCIENCE AND MATHEMATICS so useful in this work that he has ordered the journal sent regularly to his desk.

Dr. M. N. States has resigned his professorship in physics at the University of Kentucky to accept the directorship of research and development of Central Scientific Company, succeeding Dr. P. E. Klopsteg who became president of that company a year ago. Dr. States assumes his new duties at the close of the present school year.

DENTISTRY AS A CAREER.

With 67,000 dentists, 1 to every 1,700 persons, America leads the world in dentistry and dental training, according to the Office of Education, United States Department of the Interior, in spite of the fact that it has been estimated that only one-fourth of the American people receive dental service.

"Dentistry," a career study of the Office of Education prepared by Dr. Walter J. Greenleaf, higher education specialist, makes this information known.

While the average ratio of dentists in the United States is 1 to every 1,700 persons, there is only one dentist to every 4,000 persons in Alabama, Arkansas, Mississippi, and South Carolina; and one to every 3,000 persons in Arizona, Georgia, Kentucky, New Mexico, North Carolina, Texas, and Virginia. There is said to be only one Negro dentist to every 8,500 Negroes.

America's average dentist is a graduate of a reputable dental school, has passed a licensing examination, and usually registers annually with some State officer. He receives an average annual income of $4,148, and generally practices his profession in or near a city.

Thirty-eight institutions in the United States offer professional training in dentistry, 31 of which are rated Class A, 6 are rated Class B, and 1 is unclassified.

A minimum college requirement of five years is effective at the present time in 27 dental schools. The "1 to 4 plan," one pre-dental year and four professional years, is the most common.

THE TEACHER OF SCIENCE AND THE LANGUAGE PROBLEMS.

By H. G. Paul,
University of Illinois, Urbana, Ill.

I welcome the opportunity to discuss with you this morning the question of the relation of the teacher of science and the language problem, welcome it since it has been a source of irritation in many schools because instructors have not always viewed the matter in a large way, and because we must carefully and honestly regard this subject from a great many different angles if we would arrive at any satisfactory method of procedure. Too frequently the science teacher has been rebuffed by the teachers of composition when he has sought some means of cooperation for improving the pupils' use of the vernacular, and too frequently the English teachers have been met by the rebuke, "I am a teacher of science, and instruction in English is not my job—it is yours."

In seeking to analyze this problem, for it is indeed a complicated one involving many tangled threads, perhaps we may well start by recognizing that one of the functions of the school is to teach the pupils to use correct speech, *correct,* let me emphasize in distinction from *precise* and *vital* speech, correct in the sense in which one speaks of correct table manners or correct dress. For when we pause to consider the nature of correct speech, we at once recognize that it is not governed by hard and fixed laws, but is primarily a matter of convention—of agreement among those who use English, just as nine innings are a convention among those who play baseball. Certain items in our teachings are fixed and immutable. All the legislatures that ever met in Tennessee might pass resolutions that six times seven should equal forty-three, but these would not affect in the least the prerogatives of forty-two. Nobody could legislate the square inscribed on the base of the right-angled triangle into the position of equality with the sum of the square of the other two sides. As Emerson might have put it, these matters stand fixed in the plan of the universe.

But in many other respects our daily lives are rightly governed by conventions. As you and I go motoring down the highway and see another car approaching, we do not

stop and wonder whether its driver will try to pass us on the right or on the left. By the conventions of driving we feel sure that if he is sober he will turn to the right, and on that assumption we act a dozen times to the mile. There is nothing sacred about turning to the right; in England and in Sweden they get along just as well by agreeing to turn to the left; the important thing being that there should exist agreement.

Socially, these conventions have made for easier and frequently for pleasanter living, for back of them in many instances will be found ample justification for their being. Less essential but none the less powerful are many of our conventions of dress and table manners. These may be able to produce no very convincing arguments when brought to the bar of logic and required to justify their existence, but they have behind them a large body of public opinion which gives them place in the unwritten laws of society. Permit me to illustrate the idea I am trying to enforce.

Once a fellow faculty member was railing against our slavery to social customs, especially to customs in the matter of dress, and expressed his willingness to sign a sartorial Declaration of Independence. "Well, if you feel that way," I ventured to suggest, "I will give you twenty-five dollars if tomorrow morning you will appear sans collar and tie and pass the morning thus in your three classes." If I had not been quite sure that my friend would realize that such an act would harm him much more than he would gain from the money, I should, of course, have been less prompt to make the offer. Table manners and certain matters of personal hygiene are among those conventions which have come to have an immense value both in business and in society, and many a man today is more badly handicapped by reaching for food on the outlying parts of the table than he is by being afflicted by some of those diseases which are advertised as hitting four out of every five of us.

Now there is nothing morally wrong in saying, "I seen my duty and done it," or in talking about the "pints of a picter" or the "pizen of a sarpent." The worst that can be said against the man using the pronunciations just cited is that he is out of date—he is dressing his words in the styles of pronunciation current two centuries ago. But that people

do prize and prize very highly this correctness of language is beyond dispute. In his famous characterization of the educated man Nicholas Murray Butler places first and foremost this correctness in the use of language that is at present forming our theme. I can cite, and I know you can confirm me, instances of teachers of science failing to gain otherwise deserved advancement because they commit assault and battery upon these decencies of speech nearly every time they open their mouths.

So far, I feel, most of you will be in quite hearty agreement with these platitudes which are none the less true and vital because they are platitudes. My next suggestion may have received your less serious consideration, namely, that in this matter of correctness in speech, just as in correctness in dress or in table manners, some offenses are much more serious than are others. For example, some of the finer distinctions formerly taught concerning the use of *shall* and of *will* seem to be losing their validity; whereas such a statement as, "He has came and he has went," or such pronunciations as the slovenly *alfalfie* and *sodie* and *Peorie* are for the pupil serious social and business handicaps, the removal of which becomes the urgent business of the entire teaching force.

Let me repeat, "the urgent business of the entire teaching force," for it is utterly impossible for any one instructor or any one department to accomplish alone the needed reformations. Much of the knowledge that most of you impart is planted without much social resistance. The child comes to school, let us say, without having formed any bad habits with reference to arithmetic or geography or science. When you attempt to teach him such a combination as H_2O, there is no little social imp yelling continually O_2H; but if you wish to realize the legions of linguistic hoboes, just awaken your senses as you walk down the street, or notice the speech current even in the corridors of your own school.

"Well, what shall we do about it?" you ask. The one answer is, Plan a cooperative campaign in your school against incorrect language. Do not be too fussy; do not be overambitious. After careful observation of the speech of the school, decide what are the three or four most glaring linguistic errors and on these concentrate your attack. A

Better English Week is, of itself, of little worth; it must be followed by a Better English Year. A few verb forms, a misused pronoun, some commonly mispronounced word,—this modest program will furnish plenty of exercise for all the enthusiasm of the school.

After the campaign has been planned, the cooperation of the students must be enlisted. Sales talks, posters, and repeated motivation and advertising must mark the campaign. Here the science teacher may do valiant service by helping the pupil recognize that correct English is not a matter simply for the English classes, a kind of coat to be slipped on upon entering the sanctum of the teacher of the vernacular, but a vital concern of the whole school, a demand that faces him throughout the day. When this realization has pierced deep into the lad's gray matter, stock in the correct use of English in the school will be listed as paying large and regular dividends.

So much, let us say then, for the conventional side of this matter of language, an important and thoroughly worth while affair for every teacher in the school who makes professions of an attempt to civilize the young barbarians who come under his tutelage. But much more strongly would I call your attention to another and much more vital way of looking at language. Elsewhere I have written:[1]

" 'What is it that constitutes and makes man what he is?' asks Huxley in his discussion of *Man's Place in Nature:* 'What is it but the power of language?' "

"It must be granted, of course, that occasionally we discover a mind bearing a heavy foliage of words and a light harvest of thought; but, generally speaking, it holds true that whenever we master a new word, we master a new distinction. But language is far more than the currency of speech, recording our acquisition of ideas: it is an active agent which helps mould our thoughts. How often each of us found that as in conversation with some friend we thrashed out some dark, hard problem, our minds seemed to catch fire in the interplay of words and ideas, to gain light and direction from these attempts at expresion, till even the most nebulous conceptions took clearer and sharper outlines."

[1]*Better Everyday English,* p. 1.

The old schoolmen used to debate whether there could be any such thing as thought without language. Whatever may be our answer to this problem, which has about the same practical worth as our answer to the query as to how many angels can dance on the point of a needle, we shall probably all agree that so far as the teacher is concerned, thought divorced from language would be worthless. So the teacher of science, willy-nilly, is a teacher of language. There is no use attempting to deny this: he cannot be a teacher of science without being a teacher of language.

As a teacher of language he introduces pupils to a new group of names. I use the word *group* advisedly, for many names live not as hermits but as members of peculiar colonies. Thus, when I mention *gridiron, touchback, tackle, fake kick,* etc., all of us at once recognize that I am using a vocabulary peculiar to a particular sport. In fact, this habit that words have formed of living in groups is so prevalent that we have invented the term *nomenclature* to designate such a family or hive.

This vocabulary of science is an esential part of the equipment of the student of science: these words are the tools with which he works. Seeing that the pupils master this vocabulary as each word comes to be needed in the development of the subject is one of the big jobs of the teacher of science. Realizing keenly the truth of this necessity, the good teacher will carefully introduce those strange words which are to appear in the morrow's lesson. Here, as elsewhere in our instruction, an ounce of prevision is worth a pound of revision. Students must become properly acquainted with these new words by seeing them on the board, hearing them pronounced, and repeating these names, just as we do in that excellent teaching game which constitutes a proper introduction of one person to another. Sometimes a knowledge of the history of a word—an acquaintance with its ancestry and family—may be worth much more than the cost of the time spent in imparting this information. Often a surprisingly effective and rapid review of a section of a subject may be had by calling upon a class to write the explanation of some six or eight of the terms involved.

Here, again, the real teacher of science may do a good

piece of work, logically and linguistically, by training boys and girls to make proper definitions. All of us, whatever our departments, are interested in impressing upon a student the nature of a good definition, with its inclusion of the class term plus the peculiarly differentiating characteristics. All of us must set our instant stamp of disapproval on what I have sometimes called the *when* and the *where* definitions. Such, for example, is the statement that "Intoxication is when the brain is affected by the action of certain drugs," which might much better be, "Intoxication is a state of the brain caused by certain drugs."

Students must be trained to use words—not only nouns but also verbs and other parts of speech—that carry ideas definitely. Fuzzy wording is usually the child of fuzzy thinking. Perhaps this last statement needs the qualification that the fuzzy minded youngster has never set to the task of securing an equipment adequate for conveying his thought. As it is, many of them attempt to carry all kinds of ideas on the backs of a few poor and overworked words. *Get, fix,* and *thing* are among these sad sufferers: "Then you fix that funny little thing on the wheel." "Then you put that into something and heat it for quite a while," or "An airpump is a kind of thing that you use for pumping air." This last sentence, which is not a product of my imagination but a sentence once given in a physics class, is about as guileless and innocent as a kitten chasing its tail. But why go on? The process is as familiar as it is painful.

So exactness in the use of words is one of our best guarantees of exactness in thinking. Perhaps it is not necessary for us to carry this matter as far as Noah Webster is reported to have done, who when he was caught by his wife in the act of kissing the cook and was greeted with a, "Why Mr. Webster, I am surprised!" retorted with a, "No, madam. It is I that am surprised; you are astonished." But, joking aside, the habit of exactness in naming objects and in naming processes correctly, that mental precision in governing the words of the mouth, is one of the great outcomes of work in science that may persist long after the details of any course have grown obscure.

Some of my friends smile a bit when I say that personally I should like to see a large part of the work in oral

composition conducted by the teacher of science; but I am quite serious in my contention. Oral composition, when one has plenty to say and knows how to say this effectively, is one of the pleasantest of all indoor or outdoor games. Many teachers become so engrossed in the joys of this game, so infatuated by the sound of their own voices, that they monopolize most of the time for oral composition that very rightfully belongs to the class. Here the youngsters need no further ability in that accomplishment than to interject an occasional grunt either of assent or of dissent as may be indicated by the tone in the question proposed by the teacher, which, since it bears little concern for any real answer, might be characterized as a kind of .rhetorical question.

Ordinarily the smallest unit of composition is the sentence. As he listens to a class, any teacher who is at all sensitive to clear-cut, decent expression, is often discouraged to the point of considering whether he had not better go to Texas, there to engage in the raising of large and luscious white onions. What maimed, sprawling, incoherent sentences many students habitually pour forth! You cannot convey thought well in dilapidated, leaky sentences any more than you can convey merchandise well in a broken down old freight car. Frequently it is a good plan to require that students answer in complete sentences the questions propounded to them; but to insist that such should invariably be their practice, as is done in a certain Illinois school system, seems to me the height of absurdity.

"Who is that man standing by the desk?" and the answer, "My brother," are an example of a well worded question and a proper reply. But while we recognize and approve such exceptions, we may still affirm that the general practice of answering in complete sentences with the necessary inclusion of subject and of predicate is good for the pupil both from the standpoint of the formulation of ideas and the mastery of thought transference.

The unit larger than the sentence, namely the paragraph, offers to the teacher of science some of his best possible opportunities in training the pupils to express themselves effectively. It is immensely important that the pupil should receive repeated and frequent drill in the logical thinking

involved in the construction of a good paragraph and that he should have ample opportunities in the science class for expressing orally the thoughts he has gathered into this unit of composition.

I cannot insist too strongly on what seems to me the paramount value of a large use day after day of the topical method of recitation in the science class. I am led to this insistence from a well grounded conviction that one of the finest teachers of English that ever entered the class room in this state of Illinois was not, primarily, a teacher of English but an instructor in science. In his scheme of teaching, and he was also an outstanding teacher of science, he trained his pupils day by day to stand on their feet, incorporate their subject in a topic sentence, develop the paragraph in four or five well constructed and logical sentences, and then close with a clincher sentence. I recall well an hour in one of his classes when the lesson was concerned with the ventilation of their high school building, and I was deeply impressed with the mastery of the subject there evinced and the clear, lucid manner in which student after student handled the particular topic assigned him.

Especially is this use of the topical method valuable in times of review, for it may help the pupil wonderfully in putting into final, effective form the ideas that he has been gathering. *May help,* I said advisedly, for all too frequently instructors do not demand constantly that the student be striving for growth, for it is an educational maxim as true as it is old that real education, or growth, comes only from strain, from effort. Here the instructor must be ever rigorous in his demands for improvement, for unless the students are continually mounting from height to height, they are gaining only a sorry part of the splendid possibilities of oral composition.

One of the first aids to injured teachers who find their pupils failing here to do satisfactory work, is the device of using for each such lesson a few simple targets and of seeing that pupils shoot straight at these targets and acquire reasonable facility in hitting them. The very definiteness of the demands thus emphasized is a valiant help in making for clear, logical, forceful presentation of subject matter.

Much of what has just been said applies, *mutatis mutandis,* with equal force to the matter of written reports and papers in the science classes. But here the work in written composition may be especially helpful in one very important and unique respect, namely, in the planning and the preparation of longer reports. If a mastery of the scientific method means anything, it surely includes the orderly arrangement of materials particularly adapted to orderly arrangement. And it is indeed a fine accomplishment when a pupil has taken a subject, thought it through, arranged its parts with logic and presented these with clearness. I am tempted to call such work the very concentrated food, the pemican, of education.

Turning now to a discussion of the ways and means by which the science and the English department may be of help to one another, let us consider first the question of training pupils in handling words. Here, probably, most science teachers are quite willing to take the responsibility for teaching the words that belong primarily to the vocabulary of each particular science studied. He will also be willing to contribute to the general list of misspelled words such demons as cause trouble for pupils wherever these boys and girls may be expressing their thoughts on paper. In many instances the teacher of science I am sure, does as did a University High School instructor the other day—make the matter of the pupil's bad spelling his individual concern. Perhaps English and science and all other departments may do their most effective service by uniting in forming from the repeated misspellings of their pupils a minimum spelling list which must be mastered by each and every pupil. Here, as elsewhere in matters of written composition, the teacher of science may well turn back to the pupil work which is not in presentable shape and ask him to wash its face and comb its hair and then bring it around again. A similar treatment should be accorded any written work which shows the student has not done much forthright thinking on a level where he may very honestly and rightly be held for results. Here, as elsewhere, success lies in setting high standards and then holding to these rigorously.

With the minimum spelling list should go some list of

mechanical requirements for all written work similar to those which have been so well formulated by the University of Chicago High School. To habituate a student early in his novitiate period to meeting these requirements saves both him and his instructors no little grief later. A step higher and even of greater value is the cooperation that may be secured in inculcating the fundamentals of decent writing by the adoption of some such list as the Requirements in Form for Written Work prepared by the Illinois Association of Teachers of English and used in many of our best high schools of the state. Here is should be stressed, best results will follow only when these requirements have been definitely explained and drilled upon in the English class and are then made actual, honest-to-goodness Requirements of every department in the school. Pupils are surprisingly like their elders in that they live up to what is actually demanded of them and slide by when the bars are lowered. I do not believe there exists any other spring tonic half so efficacious for the mental laziness and lassitude marking the written work of many of our pupils as these same Requirements in Form for Written Work. Try them.

Into the realm of the finer matters of writing I do not believe it is fair to ask the ordinary science teacher to conduct his classes. If he helps bring them to a decent use of sentences, whole sentences—not maimed ones, that have clearness and force, he will have accomplished much. But I know of no surer way of differentiating the poor teacher of science from the good than by learning his attitude toward the question of the responsibility of the members of his department in helping their pupils give a proper habitation and a name to the concepts that have been gathering in his classes. When a teacher of science says that the expression of ideas is not his concern, we can almost invariably take at once his measure as a scientist. Surely clarity of expression, both of teacher and of pupil, is a *sine qua non* of good instruction in science. Practically every great scientist with whom I have had the good fortune to be acquainted has been an excellent writer. For example, of all the men that I have known here at the University of Illinois preeminent for their skill in the expression of their thought

none has been a more perfect craftsman than that outstanding scientist, the late Dr. Stephen A. Forbes. More than once I discussed with him the writer's art, and I am sure that the secret of his power lay in his earnest striving for clarity of expression and in his belief that there is almost always some word which fits the idea just as the skin fits the hand and is a part of it.

So far I have stressed chiefly what the teacher of science can do to improve the use of language in his own classes and in the school. Let us now discuss briefly some especially definite means of cooperation between the two departments that we are now considering. Naturally I will insist that the teachers of English are not running a laundry to take in all the soiled linguistic linen of the school. Whether rightly or wrongly they have had a feeling that cooperation usually meant all *co* on one side and *operate* on theirs. Brushing aside, however, these scholastic attempts at passing the buck, we may note that the departments may work together in deciding what pupils are so deficient in the mastery of the vernacular as to require treatment in hospital sections. Certainly every teacher is concerned with seeing that those linguistic cripples and defectives shall be placed where they may receive the very best corrective treatment the school can offer them. The benefits thus gained will go to improve the work in practically every department of the school.

Again, I am convinced that English teachers will gladly cooperate with instructors in science in making out a list of topics to be used in both the oral and the written work of the composition classes. The advantages of such a procedure are obvious; it is good for the pupil to re-approach materials already familiar but viewed from a somewhat different angle. It is a most excellent mental tonic for him to realize that his school life is not divided into narrow, water-tight compartments, but that he will be held responsible for using in other connections materials that he has supposedly mastered.

As another suggestion—teachers of science and English have in some of our better schools gotten together for cooperative work in outlining and writing up of experiments, or in planning a campaign wherein the science department

presented the materials and then the English department supervised the putting of this into the best shape. Occasionally, in some of these same schools, the English teacher takes a set of papers written in the science class (in lieu of the regular assignment). Furthermore these two departments may cooperate by seeing that interesting books dealing with scientific subjects and the biographies of distinguished scientists are included on the lists for outuside reading used in the schools. Something has already been done toward effecting this consummation devoutly to be wished—witness the *Guide to Reading* published by the Illinois Association of Teachers of English.

I might go on elaborating some of the other numerous proposals for correlating the work of these two departments. I might discuss how investigations such as the very helpful one by Ruth M. Vose, published as a Master's thesis here at the University of Illinois, have shown that in many instances energetic and resourceful principals have worked wonders in securing and in maintaining effectively the spirit and practice of cooperation among the departments of their respective schools.

That spirit of common helpfulness, that realization of a responsibility for a common task must lie at the bottom of all effective present-day teaching in our schools, just as the desire for learning on the part of the pupils must underlie any gains in education worthy of the name. Teachers of English must awake their senses to the wonderlands of science and the immense educational worth of a scientific education; they must be able to discuss intelligently the problems interesting their pupils. It is just as damnable for a teacher of English to say that these affairs of science are no concerns of his as it is for the instructor in science to say that the forms in which his students express their ideas are no concern of his. May some kind gods of education—superintendent or school board—soon remove all such teachers to some such occupation of larger usefulness as the breaking of stone.

Teachers of science! for it is to you individually that I now turn in conclusion, I know that the correction of fuzzy thought expressed in fuzzy words is a hard, man-sized job, for I have tackled a great deal of this, written by myself,

by my colleagues, and by my pupils. You cannot slough it off with a set of drills and tests of the science-made-easy brand. It requires sharp, prolonged fundamental brainwork, and most of us find this extremely exhausting. Some alleged teachers hide their heads in ostrich fashion and squeak that this is no concern of theirs. On the other hand, our better teachers of science, and their name is legion, realize how potently and vitally such a training of pupils reacts on their own thinking and speaking. He who through a long and rigid discipline has learned to accustom others to think accurately and to express themselves clearly, has given himself one of the finest possible courses in science. Such an instructor will realize the pregnant truth of Thoreau's quaint aphorism, "He who cuts his own wood warms himself twice."

PREPARATION OF AMMONIUM MOLYBDATE SOLUTION.

By G. T. Franklin, *Lane Technical High School, Chicago, Ill.*

If, in the preparation of a nitric acid solution of ammonium molybdate suitable for tests for phosphate ions, a heavy precipitate forms there is left for the worker one of two alternatives: throw the material away and try again, or dissolve the precipitate in concentrated ammonia. To throw the mixture away is rather expensive; to use it requires that the unknown solution must have a rather high concentration of nitric acid, which is not so desirable to leave to a beginner. Precipitation occurs if the nitric acid is either too concentrated or too dilute with respect to the ammonium molybdate concentration. It is the custom at Lane Tech to use the following method, which if followed carefully gives clear solution, which keeps fairly well:

Dissolve 100g of ammonium molybdate crystals in 400cc of hot water. Pour the solution while hot into a mixture of 250cc of pure concentrated nitric acid and 250cc of distilled water. The solution may then be diluted with an equal bulk of water or even more without appreciable destroying the sensitivity of the test.

HIGHEST EASTERN MOUNTAIN.

The highest mountain of the Appalachian system is Mount Mitchell, N. C., 6,711 feet above sea level, according to the Geological Survey, of the Department of the Interior. Clingman's Dome, Tennessee, with an altitude of 6,644 feet, is a close second. The average height of land in North Carolina is only 700 feet; that of Tennessee is 900 feet. Every State west of the Mississippi River, except Missouri, Arkansas, and Louisiana, has a greater average altitude than these, and Colorado's average is higher than the highest point of the Appalachian Mountains.

NEW TYPE TESTS IN HIGH SCHOOL MATHEMATICS.

By John P. Everett,

Western State Teachers College, Kalamazoo, Mich.

New type tests possess certain characteristics which differentiate them sharply from the traditional, or essay, type. One of the most striking contrasts between the two types is found in the number of details or topics which may be included. That there is an advantage, from every point of view, in covering a wide range of knowledge in an examination comes about as close to meeting the unanimously favorable opinion of both teachers and pupils as any question that may be raised. New type tests tend to multiply the opportunities for definite answers by a factor of considerable size, and this alone is sufficient to establish these types as to practice and the respect in which they are held.

That the new type has arrived and that it is found popular is more obvious than is the extent to which educational practice is justified in relying upon this form of teaching.

When anything happens in plain sight and before our eyes, we are likely to consider its exterior manifestations as being fairly well understood—until we find two observers making conflicting reports of the same occurrence. Regarding examinations we may read, "The revolt against the essay type of examinations began about twenty years ago." This idea is elaborated in such a manner as to consign the essay type to the museum of extinct or moribund curiosities.

From other sources we gain the impression that the new type examinations are among the natural and inevitable consequences of the development of psychology into something approaching a science, and that they have been evolved not from the point of departure of dissatisfaction with the old, but rather because of the observing of more facts relative to the nature of the learning processes. Understanding of the reasons for the sudden appearance of a new form of examination and an analysis of the nature of both forms are essential to an evaluation of their comparative merits.

As applied to examinations some new terms have come into prominence. *Objectivity* is one of them. It has been known for some time that when different people score the same identical paper the range of marks is very wide. That

fact has been well established, but no one seems to have gone much further. No one has attempted to determine why two teachers return marks for the same work that are so far apart, though there are some inferences from other studies that bear upon the question. If success of teaching is measured by success of learning on the part of the pupil, then that teaching seems to be most successful which most clearly recognizes and defines its obpectives. The use of the word *objectivity* as referring to an *aim* is very different from the significance of the word as referring to freedom from subjective bias of the mind. The literature of the subject of examinations heavily emphasizes one use of the word *objectivity* and almost totally neglects the other use. I do not need to go into details, because everyone who writes of the new type tests points out the fact that the scoring is mechanical, uniform, independent of the scorer.

In spite of all this it is by no means impossible that when the virtues and values of new type tests have been finally determined it will be found that their greatest contribution has been in the direction of giving to the teacher a better sense of the value and relationship of many relatively small items of knowledge and activity, thereby more or less consciously giving to the teacher's work a directness which ideals in general terms could not supply. It is quite possible that in this new type of examination there has been found a potent method for realizing the latent purpose of the course of study in the actual practice of the schoolroom. Whether a teacher makes out the questions himself or uses prepared lists he is confronted with facts and relationships in a formal manner that no other scheme of presentation has yet seemed to approach.

As to objectivity of scoring, were this the relatively important feature of new type tests which many writers imply, I should not be surprised to see these tests go the way of "the five formal steps," "the doctrine of interest," "the project method," and other creations of minds which seek an outlet for their enthusiasm, rather than an opportunity for thoughtful contemplation. One or several persons scoring a set of papers by means of a key, secures uniformity of results for similar papers, but both the key and the test itself are subjective products. An objection to an examina-

tion for which no key exists is that it fails to distinguish with precision between the worthy and the unworthy, but also a keyed test does that very same thing if the key is incorrect. Of course an obvious answer to that observation is to eliminate either by conference among several teachers or by repeated experiments, everything concerning which there is any doubt, but to do so leaves only a barren field for any type of examination. Facts we must have, but they are incidents, not the realities of life for most of us. The difference between $75 and $50 is $25, regardless of debate, legislation or referendum, yet the fact is insufficient to determine whether I shall pay the smaller or the larger figure for an overcoat. For a given outlay one secures less milk at eight cents a pint than at 13 cents a quart, yet many people properly purchase their milk by the pint.

Comparable situations in mathematics are encountered in such attributes as form of statement, order of presentation of facts, general appearance of a paper, and spelling. In geometry, definitions and postulates frequently belong to a realm in which there is to be found almost anything except considerations of mathematical precision in the sense of necessary conclusions. Yet they have to be accepted as a part of mathematical reasoning. Is a demonstration complete which lacks a proof of the fundamental congruence theorems where congruence is to be established? Is a triangle a special form of trapezoid? Shall an equation be solved by "transposition"? by the use of axioms, or by resort to fundamental concepts of the mind in other terms? None of these are "objective" questions, yet questions of this nature are woven into the very fiber of mathematical teaching and learning.

The significant trend of educational procedure is away from the authoritative and toward the reflective. Democracy is being realized in the class room in many ways which practice the pupil in making choices of his own. It does not look as though schools would ever be content with teaching or practicing merely in the realm of factual experience. If this trend of educational procedure is real, then any device which depends for its successful operation upon material which does not permit of fine distinctions

which throw the final conclusion in various directions is bound to occupy a subordinate position.

It may be argued, not without plausibility, that mathematics belongs to the realm of facts. What could be more factual than "the science of necessary conclusions"? But mathematics of the secondary school is not "pure" to the extent of segregation from human interests and applications. It may be true that "figures do not lie," but until mathematics has been refined to such an extent that "liars do not figure" it would seem to be necessary for schools to give consideration to the premises upon which conclusions are based, as well as to the processes by which their conclusions are obtained. The mathematical class room, then, is not the place of *certainty*, but only the place where there is *some certainty*.

If the new type tests are to survive it appears that they must possess other and stronger virtues than are to be found in objectivity of scoring. The professional educator has a naive respect for statistics amounting often to adoration. The teacher of mathematics, especially of elementary mathematics, must concern himself with human relationships as well as mathematical processes, and if he does he finds the realm of objectivity claiming only part of his attention.

That the sum of +2a and —7a is —5a is an objective fact, but this fact alone carries with it no implication whatever of the meanings involved either in the number expressions themselves or in the mathematical operation involved. To such an extent is this true that one may read in a new, and apparently fairly popular, text book for ninth grade algebra this statement, "In arithmetic all numbers are positive; algebra uses also negative numbers." This is the result of a kind of teaching and of thinking in terms of the objective alone. A person who is content to see in directed numbers the kind of meaning conveyed by the statement quoted could easily put all of his knowledge of directed numbers into a classification of situations which would include only statements and results capable of objective determination and expression.

Possibly we shall some day reach a stage of intellectual accomplishment where the general as well as the individual

ideas of mathematics are capable of reduction to measurable units, but that time does not seem to be in sight at present.

The statement may be made, "The number +6 as a directed number in algebra can never under any circumstances represent what the number 6 does in arithmetic." As a matter of fact this statement is either true or false and can be so marked, but that mark is a *mark* and nothing more. The correct mark would locate a pupil nearer the goal of a high score than would the incorrect mark, but no single stroke of the pen is sufficient to determine in such a case the difference between understanding and ignorance in the same or different individuals. Were I a teacher in a position where the effectiveness of my work were to be measured by the showing which my pupils were able to make in an objective test I should probably teach them how to mark a statement such as the above, and if I succeeded I should thereby pass on to my reward of promotion and enhanced salary, but if anywhere there is recorded the result of effective teaching, that space opposite my name would be blank or black—and deservedly so. Intelligence, whatever it is, certainly involves the correct response to a simple situation, but also it requires the organization of responses themselves in complex situations which require selection and elimination and sequential arrangement of relationships, as well as computations and conclusions drawn from isolated conditions.

In other words the situations of life to which mathematics applies are complicated—complicated as to meanings and as to length, and *length* is an enemy of the new type examinations.

It is possible to isolate into separate parts every fundamental operation that enters into any ponderable situation, however complicated, and thereby to determine whether a pupil is in possession of the elementary ideas necessary to a satisfactory treatment of the situation; but possession of these ideas furnishes almost no assurance whatever that the complete situation lies within the grasp of the pupil. Herein are to be found the most striking evidences of strength and glory, and of weakness and inadequacy of each type of examination. The essay type, which in mathe-

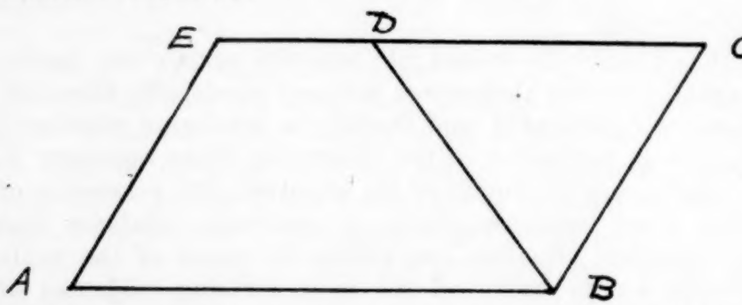
matics is often modified into the solution of several-step problems or the proof of a theorem depending upon several preliminary ideas, requires and exhibits almost any degree of organizing ability or ability to descriminate between the essential and the irrelevant but at the same time fails to indicate to what failure is due, or where trouble lies. The new type test does for the pupil precisely what the essay type fails to do and at the same time the new type test fails to accomplish what the essay type does.

The statement which has just been made necessitates an answer to at least two questions that are sure to arise: Question No. 1—Is not the answer to a problem, however complicated, a piece of objective evidence? The answer is *Yes*, but a complicated problem is not of a part with the new type tests. Furthermore such a problem if encountered for the first time, calls for the use and evidence of powers of discernment and of adaptation which extend beyond and are incapable of expression in terms of, simple, fundamental, or unitary ideas.

Question No. 2—Is it not possible to so phrase new type questions as to call for discrimination, evaluation of relevance, and organization?

Again the answer is *Yes*, but followed by the qualification that if the question is so phrased as to require the pupil to make notations on paper of more than trivial computational nature in order to reach a conclusion, then the question is no longer new type—it partakes of all the essential characteristics of the essay type. For instance:

ABCE is a parallelogram. BD is longer than BC. Is ABDE a trapezoid?



This is a typical new-type question, not too easily answered, but calling for no complicated sequential deduc-

tions. Since it is a sensible question which presents concisely all of the conditions involved and may be answered concisely it properly may be regarded as a good question.

It is one of the most difficult in a list of 84 geometry questions which received honorable mention in a nation wide contest. It evidently goes about as far as the author and the judges thought that questions should go. Note that the answer calls for the exercise of imagination, knowledge of what constitutes a trapezoid and the exercise of discriminating judgment as to whether or not the properties of a trapezoid are present; but of reasoning in the sense of organization of ideas there is slight trace.

The objective evidence that I have for calling this question one of the most difficult in the set is that the author's own key is probably wrong. The directions under which the question appears are: "If enough facts are given to determine the nature of the figure, answer *Yes;* if not, answer *No.*" The answer in the key is *Yes.* However, neither the key, the question or the author of the question is to be condemned on account of the error. This simply illustrates what has been said before: Namely, that the values of the new type tests reside not more in their objectivity of scoring than in the opportunities which they afford of calling attention to a multiplicity of facts or of thought provoking situations which no other teaching device has ever supplied.

The general purpose which tests are designed to serve seems to be in some danger of modification in a not wholly desirable direction by the new type test. I refer to the uses which examinations may serve as direct teaching adjuncts, as distinguished from employing them to determine a mark or passing grade. When used for diagnostic purposes, the tests or exercises are usually placed in the hands of the pupils after they have been corrected, but often these questions are sedulously guarded not only before, but after the examination, and the examination itself is conducted under a limited time schedule which is designed to discourage the retention of a definite idea of the questions.

I know an able and distinguished professor of the philosophy of education who gives new type examinations, but he requests his students not to discuss the questions among

themselves or with others, because that would destroy the usefulness of the questions for future examinations. Of course, the inference is that it would be difficult, if not impossible, to construct another set. If this is the case with the philosophy of education, where there are no practical or theoretical limitations to cramp the style of the professor, what is the teacher of geometry to do, with a subject which every curriculum maker from Plato down to the year 1931 has tried to confine within ever narrowing boundaries? or what can be expected of the teacher of algebra, where elimination of topics and processes has been one of the favorite indoor sports of educational reformers for twenty years?

The problem is a real one. The making of new type questions is one of the most entertaining exercises in which any teacher can engage. A set of such questions calls for the exercise of a considerable amount of time, but usually it is to the teacher a satisfactory expenditure of energy. However, after doing a good piece of work in devising a set of questions, it is probably the usual thing for a teacher to feel that he could not possibly create a parallel set that would be as good. The natural consequence of this feeling is that the pupil is given the benefit of his score, without the privilege of examining his own paper after it has been corrected. Such practice deprives the test of much of its possible value to the pupil, and if it is necessary to resort to such protection of questions, that fact will constitute a serious indictment of new type tests.

A more likely solution of the difficulty would seem to lie in the discovery that the number of possible questions is much greater than might be supposed. There was a time when mathematicians jealously guarded their solutions to problems, but that day has long passed, largely because it is now generally recognized that mathematics offers plenty of opportunity for the outlet of genius regardless of how far any individual may progress. In something the same way interchange of lists of questions is likely soon to bring about a realization that there is available such a wealth of question material that there is no more reason for guarding new type questions that have been used than there is for not

publishing questions of the College Entrance Examination Board or of the Board of Regents.

The promiscuous use of the word *standard* has probably done much to create a false impression of the sanctity of sets of questions. There are some tests that have a proper claim to the word, but there are others for which the suspicion is not wanting that the nerve of the authors or the cupidity of publishers is about all that makes the tests "standard." A hopeful indication of a sane use of new type tests is to be found in their inclusion as part of the regular texts of some books that are appearing on the market. Some of these tests display ingenuity and scholarship of a high order and the openness with which they are presented is evidently in the minds of the authors, an indication of their value as teaching devices.

It is not impossible that there may develop an industry in furnishing high schools at intervals, from some central source, sets of questions, which are to be released at certain dates. Something of that kind is done now in the case of certain forms of college entrance examinations. It would be possible for national societies for the promotion of education to set up such bureaus—though I am not predicting that this will ever be done.

According to some advice all new type question sets should be evolved locally, so as to meet local conditions. This view in itself would seem to be a strong indication that objectivity is another name for local subjectivity. It is possible that new type tests may develop a technique of such a specialized character that their production will tend toward centralization in much the same way that many activities of today which formerly were localized are now concentrated and radiated by distribution of the finished product. An alternative of this might be special courses in schools of education devoted to examination techniques. At any rate the new type tests have already brought to the front a new use for a goodly array of words, such as: *validity, reliability, objectivity, comprehensiveness, facility, economy, utility, and finally, rapport.*

It is probably fortunate for many people that they have, so to speak, gotten their hand in before they knew with what they were contending, but the very assemblage of

these words is an indication of the extent to which there is prevalent a new sense of scientific possibilities and practice in education. Methods and forms of written examinations could not well do less than reflect and keep pace with progress and improvement in other phases of instruction. If it requires special training and education to write up a set of examination questions, that is another evidence that teaching is becoming a profession.

Reliability as applied to examinations, is capable of being reduced to numerical terms. Thus we speak of an examination as having a reliability of 62, or of 80, or of 95. Any person by applying himself to the task may measure the reliability of a set of questions, but it is not certain that the figures mean anything at all. A gravity scale is not unreliable if it records different weights for two articles unless the two articles really weigh the same. Nor would a gravity scale be unreliable were it to record different weights for the same article were one reading to be taken at the level of the Dead Sea and the other at the summit of Mt. Ararat.

The theory and application of statistical method as employed in education is based upon the presumption that the product of education is a something that can be measured if we know enough about it. We may accept this statement as a working hypothesis without in any way strengthening the claim of measures of reliability to acceptance at anything like their face value. If every time we attempted to weigh a gravimetrical object, the very act of weighing modified the weight of the object, that would not mean that the object could not be weighed. It would mean, though, that our present scheme of record of weight would have to be changed. Where now a simple ratio suffices that would no longer be the case.

In attempting to measure the product of education we seek to employ the techniques which apply to nature and to natural phenomena. Perhaps this is possible, but I am not sure. But are not the mental attributes of man themselves nature and natural phenomena? Even if we answer the questions with a decided *Yes,* it is possible that the truth has not been expressed. Certainly the truth has not been expressed if man is endowed with a creative power which by its own exercise brings into a complete creation of nature

something not there before. Education in a conscious attempt to give to present and future generations the benefit of social experience may have started something different and bigger than mere modifications or discoveries of things already in the world, and one of these things was *eternity*.

Such ideas as those of transcendental number or that the whole is equivalent to one of its smaller parts are new inventions or new discoveries. C. J. Keyser says that they are merely discoveries of things that were here before. If that is true it simplifies things considerably for the statistician, as well as for the psychologist. On this assumption he who sets out, for instance, to measure the reliability of a written examination has merely to browse around with sufficient discernment and discover what he needs and then use these discoveries intelligently.

The inquiry into "what's the use" is the beginning of the discovery of the answer to the question, and the inquiry should not be condemned if it uncovers first the material and the sensationally obvious; but we should recognize that it is in the nature of the case that the early revelations of a new technique of investigation must be superficial. But superficiality is a relative matter. However unreliable may be a certain measure or statement it is not superficial in a derogatory sense if we recognize that it represents progress, but not finality. We should look at new type examinations with their statistical accompaniments in that light. Salvation is to be accelerated by formulas of procedure, but its spirit is likely to be realized only through recognition of that wherein is to be found the revelation of its essence. For us the contributions of the new type tests now appears to be in the light which they shed upon, and the assistance which they furnish in, determining what are the objects of education.

UNEARTH CITY OF DEAD ON AEGEAN ISLAND.

Digging on the island of Lemnos in the Aegean Sea, the Italian Archaeological Institute has unearthed a necropolis which appears to be of considerable importance archaeologically.

The burials in this city of the dead are of a non-Greek race. The language, judging from the inscriptions, was surprisingly similar to the Etruscan. And most of the urns, weapons, objects of gold, and ceramic articles are so similar to Etruscan art that the possibility has been suggested that this people belonged to the race which later emigrated to Italian Etruria. Prof. A. Della Seta has been in charge of the excavations.—*Science Service.*

COMPARATIVE MERITS OF PHYSICS TESTS.[1]

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Introduction. As originally planned, this study was intended to cover all fields of science tests. It was found however that time limitations precluded the completion of the larger topic. This report is therefore confined to standardized tests and scales in high school physics.

Scope of the Study. The full report, of which this is an abstract, evaluates the existing physics tests according to six criteria:

1. Validity.
2. Reliability.
3. Ease of administration.
4. Ease of scoring.
5. Character of norms.
6. Cost.

The following discussion will be largely confined to the first two criteria, viz., validity and reliability.

Tests and Subjects. The tests administered and evaluated were:

1. Columbia Research Bureau Physics Test, Forms A and B.
2. The Harvard Tests in Elementary Physics, Forms A and B.
3. The Hughes Physics Scales, Information R, Division 1.
4. The Hughes Physics Scales, Thought R, Division 1.
5. The Iowa Placement Examination, Series PT1, Revised, Forms A and B.
6. Black and Cushing Test in Applied Physics (in a preliminary experimental edition supplied by the authors with the comment that the final edition would not differ importantly from the form used here).

The above tests were given in the order listed, Form A being followed by Form B (if any). Tests were given on alternate days except in one instance. The physics classes of five large California high schools were used in order to secure as broad a sampling as possible. The numbers of pupils used are noted in connection with the tables to be presented.

[1]Paper read by title before Section Q of the American Association for the Advancement of Science at the Des Moines meeting, December 26-28, 1929.

[2]Mr. Meyer is responsible for the actual computations given here. Mr. Ruch planned the study and directed the statistical work.

Validity. The ideal method of testing validity (the degree to which a test measures what it purports to measure) is that of correlating the scores yielded by a test against an outside criterion of validity. In practice such a criterion is seldom available. In the present case an indirect measure of validity is attempted through the average intercorrelations (raw and corrected for attenuation) of the several tests. The average correlation of each test with the remaining tests *does* provide a measure of validity upon the assumption that the composite of many tests is a criterion of validity.

One fact should be noted in connection with the Hughes Scales in studying the tables which follow. These scales call for transmuting the raw or obtained scores into derived or weighted scores, the weighting being done upon a basis of difficulty. The weighting of test scores, although much employed formerly, is gradually falling into disrepute. Douglass and Spencer and one of the present writers (G. M. R.) have gathered evidence which shows that the weighting of scores is of little or no value; in fact the validity and reliability may even be lowered by such devices. For this reason the statistical treatment of the Hughes Scales is dual, the raw and weighted scores are both used in order to throw further light on this question of weighting. A footnote to Table I calls attention to the effect of weighting on validity coefficients.

The following key will be needed in connection with Tables I and II.

1. Harvard
2. Black and Cushing
3. Columbia
4. Iowa PT1, Rev.
5. Hughes Information (Raw scores)
6. Hughes Information (Weighted)
7. Hughes Thought (Raw scores)
8. Hughes Thought (Weighted)

Table I shows the intercorrelations and average intercorrelations of the tests. The following conclusions summarize the main points of this table:

(1) The intercorrelations are usually fairly low, indicating that these tests measure rather different functions.

(2) The highest correlation (0.77) is found between the Columbia Research Bureau Physics Test and the Iowa Placement Examination, Physics, PT1, Revised.

(3) The lowest correlation (0.42) is found between the Harvard test and the Hughes Information Scale (weighted or Hughes' method of scoring).

(4) The Harvard test appears to have the lowest validity, judging by the average intercorrelation with the others.

(5) The Black and Cushing, Iowa, and Columbia tests appear to be highest in validity, in the order just given.

(6) The Hughes Scales would gain somewhat in validity if scored simply "Number Right."

It is well known that the correlation between the scores on different tests is diluted by the errors of measurement in both tests correlated. The amount of this dilution (attenuation) can be estimated and corrected for (at least in theory) by the use of the reliability coefficients (see Table III). The corrected coefficients provide us with measures of the probable correlation which would be obtained if we had true measures of whatever functions the several physics tests actually do measure.

The case may be stated another way. The lack of perfect correlation between any two of the tests is due to two general causes: (1) errors of measurement—which would tend to disappear if very long tests were employed—and (2) genuine differences in the functions tested by the various tests. Thus, when allowance is made statistically for (1), lack of perfect correlation implies difference in the ability or function tested.

TABLE I—INTERCORRELATIONS AND AVERAGE INTERCORRELATIONS

Test	1	2	3	4	5	6	7	8	Average
1	....	.69 ± .037	.58 ± .048	.64 ± .043	.45 ± .057	.42 ± .059	.50 ± .054	.52 ± .052	.57
2	.69 ± .037	....	.77 ± .029	.70 ± .036	.69 ± .036	.66 ± .040	.60 ± .046	.59 ± .047	.68*
3	.58 ± .048	.77 ± .029	....	.64 ± .042	.63 ± .044	.62 ± .044	.62 ± .044	.60 ± .045	.64*
4	.64 ± .043	.70 ± .036	.64 ± .042	....	.63 ± .043	.64 ± .042	.67 ± .040	.67 ± .039	.66
5	.45 ± .057	.69 ± .036	.63 ± .044	.63 ± .043	....	....	.76 ± .031	....	.63
6	.42 ± .059	.66 ± .040	.62 ± .044	.64 ± .042	....	....	....	.70 ± .037	.61
7	.50 ± .054	.60 ± .046	.62 ± .044	.67 ± .040	.76 ± .031	....	....	....	.63
8	.52 ± .052	.59 ± .047	.60 ± .045	.67 ± .039	....	.70 ± .037	....	....	.62

*In computing the average intercorrelations the weighted values were used for the two Hughes Scales. If the raw scores had been used the starred values would have been larger by 0.01, thus indicating a slight lowering of the validity by the attempt of Hughes to weight the elements of his test. A better scoring would be simply the number correct. The unweighted or raw scores obviously are simpler and more economical of time, not to mention the freedom from statistical logic not easily understood by classroom teachers.

The appropriate formula for correcting for attenuation due to errors of measurement, for the present cases, is:

$$\bar{r}_{\infty\infty} = \frac{r_{A_1B_1}}{\sqrt{r_{A_1A_2}\ r_{B_1B_2}}}$$

In this formula the numerator term represents the correlation of any two tests and the denominator term represents the geometric mean of the reliability coefficients of these two tests.

Table II shows the *average* of the corrected coefficients of each test against the remaining tests. The values are analogous to the last column of Table I except that we are now dealing with the values obtained by the above formula instead of those actually obtained by correlating the test scores.

TABLE II—AVERAGES OF THE CORRECTED COEFFICIENTS; EACH TEST AGAINST THE REMAINING TESTS. (SEE PAGE 677 FOR THE NUMBERING OF THE VARIABLES).

	Test 1	2	3	4	5	6	7	8
Raw Scores	.70	.86	.80	.77	.75	...	.77	...
Weighted Scores*	.71	.87	.81	.79	...	.76	...	.79

*The weighted scores refer only to the Hughes Scales, as before.

The principal conclusions to be drawn from Table II are:

(1) The lack of high correlation between the various tests is not principally due to unreliability but indicates marked differences in the abilities tested.

(2) No two of these tests measure even approximately the same thing.

(3) Coefficients falling between 0.70 and 0.87, as these do after correction for attenuation, suggest that these tests, taken by pairs, cover rather less than fifty per cent identical functions, i. e., they are roughly one-half identical and one-half different in functions measured.

(4) The relative placements of the several tests are practically the same as was found in Table I when obtained (raw) coefficients were considered.

Reliability. Table III shows the reliability coefficients, means, and standard deviations. Reliability is defined as the degree to which a test measures whatever it does measure, not necessarily what it purports to measure. Reliability is usually measured by correlating two equivalent forms of the same test. The reliability coefficient is therefore a measure of the stability or consistency of scores under repeated measurement.

TABLE III—RELIABILITY COEFFICIENTS, MEANS, AND STANDARD DEVIATIONS, ETC.

Test	N	M_a	M_b	SD_a	SD_b	r	PE (score)
1. Harvard	89*	32.1	32.3	7.6	7.8	.80	2.3
2. Harvard	188	30.8	30.8	7.6	7.9	.76	
3. Black and Cushing	89	32.4	30.5	6.6	7.5	.77	2.3
4. Black and Cushing	132	32.2	30.1	6.7	7.7	.81	
5. Columbia	89	40.7	37.4	22.2	23.7	.78	7.2
6. Columbia	200	37.0	34.1	22.5	23.1	.81	
7. Iowa Placement	89	61.7	67.9	27.1	28.2	.89	6.2
8. Iowa Placement	172	60.8	56.2	25.7	27.4	.89	
9. Hughes Information (Raw)	89	17.1		5.2		.88	1.2
10. Hughes Information (Raw)	204					.86	
11. Hughes Information (Weighted)	89	79.5		8.7		.81	2.5
12. Hughes Thought (Raw)	89	15.2		5.4		.82	1.6
13. Hughes Thought (Raw)	192					.85	
14. Hughes Thought (Weighted)	89	82.4		8.8		.75	3.0

*89 pupils took all tests. This figure includes the complete records. Varying numbers of additional pupils took certain, but not all, of the other tests.

The following statements cover the facts about the relative reliabilities of the tests. (Note: the order is based upon the 89 pupils who took all tests. The parenthetic values are those of the larger groups.)

(1) The reliabilities from highest to lowest are:

Iowa Placement Examination	.89 (.89)
Hughes Information (Raw scores)	.88 (.86)
Hughes Thought (Raw scores)	.82 (.85)
Hughes Information (Weighted scores)	.81*
Harvard	.80 (.76)
Columbia	.78 (.81)
Black and Cushing	.77 (.81)
Hughes Thought (Weighted scores)	.75*

(2) The Iowa Placement Examination, Physics, PT1, Revised, proved most reliable.

(3) The Hughes Thought Scale is least reliable.

(4) The other tests differ little in relative reliability.

(5) More reliable results will probably be secured if the weighting scheme of the Hughes Scales is abandoned in favor of the simpler "Number Right" method of scoring. The gain is represented by an increase in the correlation of 0.07 in the case of each scale. This adds to the work of Spencer and Douglass who concluded that weighted and unweighted scores correlated so highly that the weighting was unimportant. These data suggest further that the weighting may even reduce the reliability.

*The star indicates that the official method of scoring was used here, viz., the weighted method of Hughes.

FROGS AND TURTLES DEAF TO HIGH TONES.

Bullfrogs and turtles are unable to respond to human speech or other high tones as do mammals but only deep sounds like the low croak of the bullfrog himself, Drs. E. G. Wever and C. W. Bray of Princeton have reported to the New York branch of the American Psychological Association. This high tone-deafness of reptiles and amphibians was discovered in the course of a series of experiments which the scientists have been conducting to determine by what process hearing is made possible.

The nerve current carried by the auditory nerve is similar in general character to the sounds stimulating the ear of the animal, it was indicated by the experiments. For impulses initiated by speaking into the ear of the frog made the speech audible, after amplification in a telephone receiver hooked up to the auditory nerve. It did not sound like speech, however, but merely like a buzz. For the turtles, the speech could not be understood but was clearly distinguishable as someone talking. The impulses when amplified about 800,000 times can actually be measured by a cathode ray tube measuring device for electrical current, Dr. Wever found.

ELECTROLYSIS.

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THE GENESIS OF A THEORY.

The development of the theory of electrolysis offers a splendid example of how general notions are modified and changed to fit new facts. The first record (1) of electrolysis details how Deimann and van Trootswyck closed one end of a glass tube with a stopper through which was inserted a wire. The tube was then filled with water and inverted in a pan of water and a second wire inserted into the open end of the tube. The wires were then connected to the terminals of a static machine, the only source of electricity known at the time, and the machine set to work. Gas accumulated in the tube. The experimenters observed that when the wires in the tube were placed above the liquid, invariably an explosion occurred. By the use of this method Ritter carried out the first true electrolysis on record. He used silver wires as electrodes and a silver salt solution as an electrolyte. Before the end of the eighteenth century Volta (2) discovered a method of generating electricity by chemical reaction. In 1795 he prepared an electrochemical series, although he left no record (13) of having observed the effect of a current flowing through an electrolyte. In 1800 the first records on the subject tell how Nicholson and Carlisle (13) demonstrated that hydrogen is obtained at one electrode and oxygen at the other when a current flows through water. They projected no theory to account for the fact.

THEORY FORMULATED.

In 1805 Grotthus announced a theory to explain the facts of electrolysis as they were then known (19 p. 4). The theory assumed that water molecules in an electrolytic cell with current turned on are arranged in chains between the electrodes, oriented so that the oxygen at one end is directed toward the anode and the hydrogen at the other end toward the cathode. When the voltage is sufficient the oxygen and the hydrogen separate at their respective electrodes.

This leaves the ends of the chain pointing in opposition to the electrostatic pressure of the electrodes, consequently the hydrogen near the anode combines with its nearest oxygen neighbor, the free hydrogen thus formed combines with the next oxygen and so on until the meeting place is reached with a similar process started by the oxygen at the other end of the chain. Presently the chain is remade but not correctly oriented to repeat the process. To "face about," according to the theory, requires an exceedingly brief time and the chain is ready to repeat the cycle again.

New Facts Require New Ideas.

During the fifty years when the theory of Grotthus was accepted, there were many arguments concerning the nature of electrolytes. In 1834 Faraday (1) formulated laws of electrolysis. Concentration polarization was observed by Hittorf (1) in 1853. This, with other facts, made the theory of Grotthus untenable. Clausius, conservative and apparently unwilling to give up the theory, projected his theory of "vibrating ions," (13) which assumed molecular motions in liquids and that impact of molecules produced temporary dissociation. The influence of the current merely directed the vibration of the ions. It is apparent to one who reads the history of the times that students were slowly working their way toward the modern theory of ionization. Clausius made a forward step toward the theory of ionization but did not reach it. In concluding this part of the discussion, it is worthy of record that some recent writers (19, p. 34) still think that the theory of Grotthus has its place in the explanation of why electrolytes, having ions in solution common to the solvent, have such high conductivities. The presence of a chain reaction in such circumstances may exist, although another explanation for such phenomena is suggested later in this paper.

Arrhenius Writes a Thesis.

Writers (9) of the history of the development of chemistry love to linger on how Arrhenius prepared a thesis for the doctorate and, in order to be diplomatic and not offend the conservative professor, modified his views and discreetly left out or hid new ideas taking deep root in his mind. A review of a paper on osmotic pressure by van't

Hoff, which fortunately fell into his hands, seemed to remove all doubts as to the validity of his new theory. This paper pointed out the relationship between osmotic pressure and gas pressure. It was quite obvious that the pressure of a gas depended upon the number of molecules and not upon the mass of the molecules. Experiments involving osmotic pressure indicated in case of non-electrolytes that the pressure varied not with the mass of the solute but with the mole fractions, in other words on the basis of the number of molecules. The abnormal behavior in this respect of certain electrolytes used suggested that the number of units which produced the pressure was increased, a fact that could be accounted for only by the dissociation of molecules. Thus in 1887 the "vibrating ion" theory of Clausius became a full-fledged theory of ionization. Thus was explained the experiment of Hittorf, in which he found concentration changes in the region of the electrodes during electrolysis. The migration of ions became a reality.

The Problem Settled?

With the establishment of the theory of electrolysis on a safe experimental basis, the problem of explaining the mechanism of electrolysis appeared to be solved. However, there are those who, like Berzelius, love debate and a thorough study into the cause of things. To them the problem is not always so simple. There appears to be full agreement as to how a current flows through an electrolyte conductor —a theory which assumes migration of ions set up by electrostatic forces, and the discharge of ions at the electrodes thus producing a continuous flow of current. Over-emphasis of this phase of the theory may cause the learner to assume that, since the ions are the electrical carrier, these ions are necessarily discharged at the electrodes (6, p. 12). That such is not always the case is easily demonstrated by using a mixture of chloride and iodide salt solutions. It is obvious that both iodide and chloride ions are instrumental in carrying the current, yet no chlorine is obtained (19, p. 25). To explain what happens when solutions of alkali sulfates and nitrates are used in electrolysis has produced considerable variety of methods in elementary works. More details are to follow.

More Facts, More Theories.

In recent years a complete extension of the electrochemical theories of Volta has been worked out in terms of measured quantity (14), (6, p. 13). Several types of polarization have been studied. Overvoltage (4, p. 70) has received much attention (3). Surface films are being studied and many theories are being formulated to account for them (12, p. 127), (3. p. 137). Atomic forms of such elements as dydrogen, oxygen, and chlorine and their relationship to metals are under investigation (3). To unravel the mystery of hydrated ions has been attempted and many facts obtained from the effort (11), (18), (19, p. 25). The effect of concentration and current density upon simultaneous deposition of metals is being measured (4, p. 320). Ionization constants of acids, bases and salts are measured in a variety of ways in different solvents. All these have a bearing upon the study of electrolysis and tend to influence theories having to do with its mechanism. One set of facts alone is insufficient to predict the course of a reaction. Many rely upon a table of electrode potentials alone. This appears to be reliable only when the elements to be deposited belong to the same group and thus have similar properties and would be expected to affect the electrodes similarly. Other facts are needed to explain the liberation of chlorine in the presence of water, the deposition of zinc in solutions of considerable acidity etc. (6, p. 255).

Analogy

It may assist the reader to get the viewpoint of the discussion to review an oxidation-reduction experiment, (10) using a platinum wire in one of the half-cells immersed in nitric acid and salt solution and a metal in the other half-cell. If a metal like magnesium is used, a rather high voltage is obtained and a brown color developing on the platinum wire in concentrated acid suggests nitrogen peroxide. It is readily demonstrated that by varying the concentration of the acid in test tubes using magnesium, a great variety of products is obtained, including hydrogen and ammonia. For purposes of discussion the equation in the half-cell with the acid is partly written as follows:

$$\overline{NO3} + H^{+} + e \rightarrow$$

Are the hydrogen ions discharged by the electrons and the atomic hydrogen thus formed reoxidized by the nitrate ions? Is it more logical to assume that the electrons decompose the nitrate ions and that the hydrogen ions merely combine with the polarized oxygen without being electrically discharged? Whatever the answers to these questions may be, it is quite evident that the mere presence of nitrate and hydrogen ions alone is insufficient to predict the final products.

Scientific Principle.

Reference has been made to the fallacy of attempting to use one set of facts alone to explain all phenomena pertaining to electrolysis. It may be assumed logically that the ions discharged are the ones that require least work in the process (8). There are cases which seem contradictory to this principle. Sodium ions are discharged in preference to those of hydrogen when a mercury cathode is used. The case is clarified by teasing a small piece of sodium in a drop of mercury. The very large amount of energy liberated by the reaction is evidence that the formation of free sodium in the presence of mercury requires very much less work than it would in the presence of platinum, and another factor which assists the formation of free sodium is the high overvoltage of hydrogen on mercury (19, p. 146). Zinc can be plated out in solutions of considerable acidity because the hydrogen may form with the zinc a sort of alloy, a zinc-hydrogen electrode on which zinc plates out more readily than hydrogen, or in other words uses less work. What is important in these examples, as in all others, regardless of the electrode potentials, alloy formation, and degree of ionization, is the fact that *those ions are discharged that require the least work under the conditions of the experiment.*

One more illustration seems appropriate. It is well known that in the electrolysis of concentrated hydrochloric acid pure chlorine is obtained with reasonably high voltages (16). On the other hand, if dilute sodium chloride solution and rather low current density are used, a mixture of chlorine and oxygen is obtained. Commercial processes for the preparation of pure chlorine use concentrated solutions of salt and high current density (3). It is interesting to note that the anode is carbon-chlorine-oxygen. There are thus

two possible factors that influence the reactions: the overvoltages of chlorine and oxygen on carbon and the exceedingly low concentration of hydroxide ions in comparison with the high concentration of chloride ions. It is no violation of the least work principle.

TEACHING METHODS IN USE.

Method I. Since it has not been proved or disproved that ions other than hydroxide are discharged in a solution containing sulfate ions, the simple explanation of discharge of sulphate ions and their reformation at the expense of water (17) may be clearer to the beginner, and at the same time within the possibility of being scientifically correct (3). It carries with it the method of thinking used by many, who think that an intermediate is necessary to explain the action of a catalyst. If the experiment is preceded by the study of the action of sodium in water, the idea that sodium ions are discharged and then the free sodium reacts with water appeals to the beginner, who has not yet arrived at the stage where he sees the inconsistency with the least energy principle of the discharge of an ion and then its immediate re-formation.

Method II. A method which assumes that sulfate ions are not discharged because it is easier to decompose water molecules is in use by many (7). This method is especially adapted to the work of teachers, who wish to emphasize the very low ionization constant of water. If one uses ordinary conductivity cells in frequent demonstrations, contrasting conductivities of various solutions, water always has an important place. The smallest lamp in these circuits does not show any conductivity with distilled water. The equations written as oxidation-reduction reactions are easily followed by beginners, who have studied elementary electricity in previous courses. They may be written as follows:

$$(1)\quad S\overline{\overline{O4}} + 2H2O - 4e \rightarrow O_2 + 4H^+ + S\overline{\overline{O4}}$$

$$(2)\quad 2H^+ + 2e \rightarrow H2.$$

The catalyst may be omitted in writing the equations. For many purposes it seems better to include it.

Method III. This method assumes that the ionization of water, which has been repeatedly measured and found to be about one ten millioneth normal with respect to each of its

ions, is sufficient to produce oxygen by the discharge of hydroxide ions and hydrogen by discharge of hydrogen ions of the water (16, p. 254). Sulphate, sodium, and other ions of like nature merely transfer the current; they are typical catalysts, which do not initiate reactions but speed them up powerfully. The method assumes equilibrium between water molecules and its ions to be maintained constant, in other words the speed of formation of ions is thought to be instantaneous. This is not unreasonable when one considers the exceedingly high concentration of the water molecules. Equations by this method are written as follows:

$$2H^{+} + 2e \rightarrow H2 \text{ (at the cathode)},$$
$$4\overline{OH} - 4e \rightarrow 2H2O + O2 \text{ (at the anode)}.$$

This method should be preceded by experiments which show water to be ionized. If a galvanometer is connected in a circuit of a conductivity cell, using small platinum wires, with current of 110 volts D. C. the conductivity of water is emphasized. Using distilled water in ordinary glass containers, about two milliamperes of current are obtained. With larger electrodes the current is naturally larger and should be used with caution with a sensitive galvanometer. Gas may be observed to form on the electrodes in these experiments.

If the electrolysis is carried out slowly it would be logical to assume that this method represents the main course of the reaction. If the reaction is carried out rather rapidly at high voltage, it is more than likely that Method II describes the main course of the reaction and it cannot be proved that Method I is not represented.

A Possible Method of the Future.

Who has not been more or less puzzled by literature on hydration of ions? The idea seems to be more or less hidden in that mystery which has to do with associated liquids and gases, and the power of certain liquids to ionize solutes. High dielectric constants of liquids seem to indicate close relationship to their ionizing power. Apparent contradictions to this principle probably have their origin in differences in hydration numbers or, analogous conditions with solvents other than water, a fact which makes conductivity

methods uncertain in the estimation of degrees of ionization. The high conductivity of solutions with ions common to the solvent may be due partly to differences in hydration numbers. Investigators all seem to agree on the order of hydration numbers of the alkali metal ions, lithium standing at the top. Beyond this there appears to be little agreement. It is natural to believe that *all ions in solution are hydrated or ammoniated or attended by analogous conditions as a logical procedure accompanying the cause of why ions exist at all.* It appears, however, unless the hydration number of some ion can be definitely fixed, we will have to work without this valuable information. If the formula of sodium ion could be proved to be NaH_2O^+, the discharge of the ion at the cathode could be easily explained as one consisting of three different kinds of atoms. The results of the experiment indicate that it takes less work with platinum electrodes to set free part of the hydrogen than to produce any other reaction that might happen on the basis of the materials involved. The ionization of water would not need to be taken into consideration. The lack of definite measurements precludes any possibility of its introduction into elementary courses.

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ISSUE NEW FILM ON GAME CONSERVATION.

Quail, grouse, wild ducks, wild turkeys, moose, elk, deer, bears, and the elusive trout and bass in their native habitats, are featured players in the new 1-reel motion picture "Forest Fires—or Game?" just released by the U. S. Department of Agriculture. The film was warmly praised at a pre-release showing before a special audience of foresters and representatives from the various bureaus of the department and from the Bureau of Fisheries and the American Forestry Association, both for its timely message and for its unusual fish and game scenes.

This film, arranged and sponsored by the Forest Service and made and distributed by the Office of Motion Pictures, Extension Service, shows how protected forests provide homes for game birds and animals and other wild life and for trout and bass in protected mountain streams, and how forest fires and destructive logging methods destroy these homes and, together with unrestricted hunting and fishing make restocking necessary.

One sequence shows how a State game department cares for fawns which are caught when young, held in corrals, and fed until large enough to shop to understocked areas. Another sequence shows how fish for restocking are raised in a Federal fish hatchery. One sees the fish eggs placed in hatching troughs, the actual hatching scenes, the fish when they have become fry, and finally the fingerlings ready for shipment to exhausted streams.

The picture was filmed in the mountains of North Carolina and in various national forests and game reservations throughout the United States. It includes much unusual fish and game photography, such as a mother quail on her nest, a mother wild goose and her family, bears climbing up and down a tree, fish eggs in the process of hatching, and various fly-casting scenes.

This film may be borrowed free, except for transportation charges. Reservations for bookings should be made with the Office of Motion Pictures, Extension Service, U. S. Department of Agriculture, Washington, D. C. Prints made from the department's negatives may be purchased at cost of printing (amounting to about $27 for a 1,000-foot reel on 35 mm. slow-burning stock) by State forestry and fish and game departments, schools, colleges, boards of education, and other authorized organizations and individuals.

WHAT DO WE DESIRE AS OUTCOMES OF OUR SCIENCE TEACHING, TODAY?

BY EDITH BRADSHAW,
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The type of education prevalent at any period of the world's history has always been the outgrowth of the immediate needs of that particular period. What are the needs of our present day society? Can we help to meet them by the introduction of new principles into our teaching, or by the more effective application of old principles?

The method of science is a fairly modern one, scarcely 400 years old. Plato regarded reality not as in the world of nature but as in the world of ideas. He says "We shall pursue astronomy with the help of problems just as we pursue geometry, but if it be our desire to become acquainted with the true nature of astronomy, we shall let the heavenly bodies alone." According to that doctrine, modern science will never arrive at the underlying truths of astronomy. The Greek Philosophers had many theories about matter, but they were altogether concerned with the theories and paid little or no attention to the matter. The first atomic theory dates back to Democritus, 420 B. C., but it was merely speculative philosophy and nearly 2000 years were to elapse before it was given the precision or quantitative aspect which would make it scientific, or of value to science.

The middle ages were colored by a spirit of "other worldliness" developed and fostered by an all powerful church. Man's focus was so completely on the life to come, and his life here was so largely concentrated on preparing for it that he had no time or inclination to develop a worldly sense of values, no sense of the past and future and no realization of his place in the stream of human life and events. Everything was taken on authority and the authority was formal and dogmatic. This kind of environment gave no opportunity for individual judgment and a narrow didactic type of schooling gradually evolved which finally spent itself in hair splitting arguments. In such an environment science found no place.

The Renaissance brought with it a new focusing on the life of this world, and an appreciation of its possibilities, and the effect was naturally felt in education, the purpose

and method of which were permanently changed. There was a break with the authority of the middle ages which marked the beginning of the modern scientific spirit. Man began to question for himself and to exercise independent judgment. The time was ripe for the introduction of scientific method of thought into life and education, which is the method *tested* thought or experimentation.

Experiment, i. e. *doing* is the keynote of science. It is only by experimentation that an hypothesis may be tested and discarded or classed as a law of nature. In the second case it automatically gives rise to new experimentation. So scientific thought is never static but has a dynamic, living quality, totally opposed to *a priori* reasoning. Francis Bacon was the first thinker to formulate the laws under which an object may be known, and he gave to thought a new emphasis by showing the world that to arrive at truth, we must *induce* general principles from specific examples. In searching for truth and reality, we find that which is significant in life.

If we are to grant that experiment is the keynote of science, we must agree that the laboratory will be the center of our science training. Book science is not science at all, but just more of that "pouring in" process which characterized the education of the past. Modern psychologists seem to agree that true education must be a "drawing out" process. The laboratory is peculiarly fitted to meet the needs of this process. Our problem is to control the process so that we may help the student to express himself in ways which will be of greatest benefit to him in later life. How can this be done?

In considering the problem we are faced with a far different world than has challenged any other group of educators in the world's history. We find that the authority of the past has practically disappeared, both in religion and government, and that the keynote of democracy is the equality of every man with every other man. It is the right of all to exercise the franchise, to serve on juries, and to hold offices of state. How can the masses be trained so that votes will be a sum total of judgments rather than an accumulation of opinions?

Then too, the spirit of communism is threatening our new

world of democracy, and if democracy is to succeed, we who believe in it must train the masses to think, to analyze,—a thing which has never before been important to government. In other types of government, it was important only for leaders of church and state to be intelligent persons; the masses didn't count. But in this day, when the vote of all decides the policies of government and when a youth of the people may aspire to the highest offices of state, the crying need of our world is for education, education for all. That is the only condition under which democracy can win out.

First of all, if we are to make the masses functioning units of government, we must train them in independent thinking. Public elections and relationships of nations are still controlled by emotion and prejudices. We are all aware of the shocking part "propaganda" played in the attitudes of nations during the late war—propaganda which has since been disproved and which was invented to sway the emotions of peoples whose rationality could be counted on not to function. Can the laboratory help here? It seems to the writer that students taught in the laboratory to weigh evidence and to defer judgment until there is a sufficient accumulation of evidence, will apply this attitude to their daily affairs of later life. Would we have wars if our leaders were of the caliber that intelligent voting would make them, and if the masses were capable of weighing the evidence in an international situation, and proceeding according to the results of their own rational findings? We certainly might have avoided the late war, if selfish leaders had not been able to play on the emotions of their respective nations. If the causes which have since been brought to light had been demanded by the world then, it is unthinkable that such wholesale bloodshed and disaster would have been allowed in their behalf. If the world is to be made safe for democracy, then it must be taught to demand and weigh evidence and to suspend judgment in civic, national and international affairs. Education alone and particularly science education can accomplish this.

What besides a critical, rational attitude in affairs of government do we need to strive for in education, today? Although we have largely discarded the old authority of church and state, we are still living in a world full of bigotry,

superstition and prejudice. It is not very long since we burned witches and accepted pestilence and plague as judgments of God, and we are still manifesting the same attitude to the extent that we regard insanity as a disgrace to be concealed and fill our prisons with law-breakers without attempting to find out the causes for their anti-social conduct and to remove them. "To know all is to forgive all" and it is as unscientific to judge a man wicked and lock him up for criminal tendencies which may be the result of pressure on the brain or of malnutrition, or glandular disturbances, as it is to think that insanity results from a person's being "possessed of devils." Only scientific training can alleviate these tendencies and difficulties.

Some one has said that science will fail without humanism. How can the scientist be anything but humanistic? It was the scholar of the old school, who spent his life absorbing book knowledge. He lived apart from his fellows and did not concern himself with them. The very nature of scientific knowledge relates it to the world about us and to humanity, and the results of scientific research inevitably react to the distinct benefit of mankind. Of what value is the study of cancer or of tropical fever except to save human lives, and of what value is psychiatry, other than that of saving human minds? The scientific person is not "cold blooded" merely because he is "cool headed," and real humanism will develop in proportion as our reason is taught to rule our emotionalism. Blind sympathy may comfort but it seldom does anything constructive, and the justice we see dispensed in the world is well symbolized as a blindfold figure.

Walter Lippman says that the acids of modernity have dissolved away all authority—including that of religion. To most of the thinking people of the world today that is true, and being true, if we wish to inculcate principles of right living and respect for law into our race, we must find an inner authority for so doing. This can come best through science and scientific thinking. Herbert Spencer says that the methods of science teach respect for law and humility in the face of laws of nature and that we achieve a "fundamental appreciation of the unknowable" (i. e. God) in science. He bases both ethics and religion on science and for many of us in the world today, it is the only way that we can accept them.

Future races may develop intuition along with reason, because reason is quite likely not the only method of arriving at reality. Neither have we any way of knowing whether the reality we achieve through reason and scientific thinking is fundamental. In education, however, we must be pragmatic, and fit the type to the need. Surely one of the crying needs of our age is for something to respect and reverence—some faith.

To summarize: The type of education of any period of the world's history has always been the outgrowth of immediate needs felt in that period. To justify our science teaching today, we must show what needs it will fulfill in our world. Science and scientific thinking did not develop until the need arose for independent judgment in the world. With that need came the scientific spirit; that of tested thought. Judgment implies the testing and appraising of situations and things. The laboratry method seems peculiarly suited to give this training, therefore we base our science on laboratory training. We feel that this method, of doing instead of absorbing, and of forming laws and generalizations from specific observations, is the very best way of developing independent judgment.

Some of the needs of the day which scientific thinking seems fitted to meet are:

1. The need of the ability on the part of the masses to weigh evidence and to *think* if they are to be functioning units in a healthy democracy.

2. The need of thought and judgment vs. emotion and prejudice in both national and international affairs.

3. The need of a scientific attitude toward crime and mental disease.

4. The need for the realization that the scientist is the true humanist.

5. The need of a new basis for faith and reverence in a world from which dogmatic authority has gone.

If our teachers are themselves students, and if they continue to be students until the end of their teaching days, if they have unbounded faith in the dignity and the greatness of their occupation, all will be well.—Principal Wallace, University of Toronto.

THE LEARNING PRODUCTS OF A UNIT OF INSTRUCTION IN MATHEMATICS.

BY C. A. STONE AND J. S. GEORGES,
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PART II.

Learning Products as Aims: Any learning, whether in Mathematics or elsewhere, is in the form of adaptations which are formed by the individual during the period that he is brought into close contact with the materials of the unit; the adaptations which are actually formed are the learning products of the unit. The individual benefits from instruction, that is, he is in the possession of learning products in so far as the instruction makes definite impression upon the character and personality of the individual, by acquiring new adaptations, forming new attitudes and habits, or else by modifying and transforming the existing attitudes and habits into more effective and more economical ones. With Morrison[15] we contend that no learning has taken place unless adaptations have been acquired in one form or another, and that real learning is a positive process the products of which are definite adaptations. The learning products of mathematics are of three types: skills and special abilities, understandings, and recognitions. The solution of the quadratic equation by factoring may be used as an illustration of these three types of learnings. The process involves the following abilities: (1) Factoring a quadratic expression into two linear factors; (2) solving a linear equation in one variable; and (3) checking. The understandings associated with the process are: (1) The factoring of the quadratic expression into two linear factors; (2) the equating to zero of each linear factor separately; (3) the solution of each linear equation for the unique value of the variable; and (4) the satisfying of the quadratic equation for both values of the variable. The recognitions involved are: (1) the scheme of reducing the degree of an equation to facilitate solutions; (2) the quadratic function as a type in representing relationships between two variables; and (3) the quadratic equation in one variable as a specific case of the quadratic function. The second item under the abilities, namely, the solution of the

[15]Morrison, H. C. ibid. Chapter II.

linear equation in turn will involve certain understandings, abilities, and recognitions, which are assumed to have been acquired in the previous units. The understandings in the solution of a linear equation are: (1) the particular operations needed to transform the linear equation $ax+b=O$, into $x = \frac{-b}{a}$; (2) the manipulation of the parameters a and b, when either or both are negative numbers. The corresponding abilities are: (1) the performance of the selected operations in finding the value of the variable, these may be a combination of either addition or subtraction, with either multiplication or division; (2) the four fundamental operations on integers, positive or negative; (3) the four fundamental operations on rational numbers, positive or negative; and, (4) the four fundamental operations on algebraic expressions, if the parameters a and b have algebraic values. Finally the recognitions involved in the solution of a linear equation which are similar to those of the original quadratic equation are: (1) the linear function as a distinct type in representing variation between two variables; and (2) the linear equation in one variable as a specific case of the linear function in two variables.

The primary aims of a unit then are to be interpreted in terms of these three types of learning products. Furthermore, the principle applies equally well to the secondary aims of the unit. For the secondary mathematical aims, as defined above, necessarily fall in this category. However, the abilities, understandings, and recognitions which are determined as definite secondary aims of the unit will be of general character attendant upon central and basic concepts, principles and processes of mathematics. The same can be said of the secondary educational aims of the unit, for they are formations and developments of desirable habits, and developments and strengthenings of powers necessary for effective and economical actions.

Informatory Aims: It is evident from the definition of the definite aims of a unit and their interpretation in terms of real learning products that such indefinite aims as the so-called mathematical values and significances are purposely ruled out by this criterion. If such aims are actually attained then they are in the form of adaptations of under-

standings or recognitions and consequently fall under these definite types, but if they are neither attained as the primary aims of a particular unit, or as the secondary aims of a sequence of units, then, their consideration as aims is foolish and misleading. Teaching for information which creates neither understanding nor appreciation is wasted effort and time, and the sooner we come to a realization of this significant pedagogical principle the better will our units of instruction in mathematics be made teachable. Vague and indefinite aims are detrimental to effective and purposeful teaching.

Skills and Special Abilities: Skills and abilities attendant upon the learning of special operations, manipulations, and methods of mathematics constitute the first type of learning products. The learning of the processes of mathematics depends upon the acquisition of certain skills and abilities which are required for the use of the process. Ability to factor a quadratic function into two linear factors, for example, is a prerequisite for the solution of a quadratic equation in one variable by the process of factoring. Abilities of evaluation of an algebraic expression for particular values of the letters, of extraction of roots, or manipulation of directed members are prerequisite to the solution of the quadratic equation by the formula. Whether the materials of a unit are readily assimilated, and thus the concepts and processes of the unit learned, depends in a large measure upon the facility with which the necessary operations are performed. The inhibitions and deficiencies in reading and in arithmetical operations render the teaching of algebraic concepts and processes difficult. Similarly, deficiencies in algebraic abilities slow up the process of teaching and learning of geometric facts and processes. The acquisition of abilities and the development of skills is necessarily a significant product in the learning of a unit in mathematics.

Nature of Mathematical Abilities: The value of a particular mathematical skill may be slight, or great; of short duration, or permanent; of only mathematical importance, or also of significance in non-mathematical fields of thought. The acquisition of the particular skill is made a definite aim of the unit not because of its contingent values, however important they may be, but because of its present and

direct uses in the learning of the whole unit. For without it progress in the learning of the unit is impossible and the whole machinery of teaching is rendered motionless. Factoring may be of very slight importance, perhaps of no importance, to the individual in non-mathematical fields. It is useless to argue the point. We may even admit the fact that to the average person in his non-mathematical activities, the value of factoring as a process is nil. Yet factoring as a process must be taught in units of instruction in mathematics. The ability to factor algebraic expressions must be acquired. Mathematical progress in the solution of equations demands it. There is no other alternative. Addition, on the other hand, is of great importance even in non-mathematical fields, at least arithmetical addition is, and the individual must be able to add not because such ability is useful in the store, the factory, the office, and the home, but because he cannot learn the particular unit of instruction without such an ability. The point is that a given ability becomes a definite aim of a unit when it is needed in that unit irrespective of its contingent values.

Abilities of Two Kinds: Each unit of instruction in mathematics calls for definite attention and concerted effort in the intelligent use of the processes and operations of the unit. The operations and processes may be entirely *new* and this calls for the formation of *new abilities* and *skills*, or they may have been taught in previous units, which calls for the use of *abilities* and *skills* already *acquired.* In the latter case attention is directed toward the increase of the rate of performance, and the elimination of any deficiencies and inhibitions which hinder the accurate manipulation of the process. The materials of the unit must provide sufficient practice to improve the rate of performance and to acquire perfect accuracy. Furthermore, the acquired abilities may be used in the assimilation of the instructional materials of the unit in new situations or the field of operation may be made more general, often including new elements for which the acquired abilities must be modified.

Arithmetical Abilities: The arithmetical abilities formed in the elementary school, that is, the ability to perform the four fundamental operations on integral and rational numbers are continued to be used throughout the secondary

school and college, and to some extent, throughout life. Though the fundamental operations have been learned and satisfactory skills, perhaps have been formed, the results of computations in the work of the secondary school are often inaccurate and absurd, and the rate of performance slow and unsatisfactory. The units of instruction in mathematics throughout the junior and senior high schools direct the attention of the pupil toward the development of these acquired abilities to yield accurate and valid results as well as toward the improvement of the rate of computation. These developments and improvements of the arithmetical abilities, already acquired are made definite aims of all units of instruction, and through the cooperation and coordination of the series of mathematical units of instruction, accuracy in computation is made an established habit, and the degree of skill and performance is increased consistent with and relative to the inherent and native abilities of the individual.

The modifications of the arithmetical abilities which have been acquired in the elementary school are brought about by the extension of the field of operations. The number system consisting of only the positive rational numbers, the whole numbers, the common and decimal fractions, and their combinations, is extended into a new system including both positive and negative rational numbers, and still later extended into the system of real numbers which includes the rational as well as the irrational numbers. Step by step the abilities to add and subtract, multiply and divide are modified to meet the new situations which the extended fields of operations demand, until finally toward the end of the secondary school period the complete number system, or the complex field consisting of the real as well as the imaginary numbers, and their combinations is open to the individual where these operations take on new meanings and become instrumental in transforming the world of sensation to the world of conception and thought.

Again the ability to add and subtract denominate numbers, to find their ratio or their products by abstract numbers is modified and strengthened by enlarging the field of operations to that of the generalized numbers, where the algebraic expression is endowed with the power of repre-

senting a class of specific or arithmetical numbers. This is a new situation and calls for the utilization of the acquired abilities in computation, in the operations on representative symbols, and in the interpretation of the results in terms of the elements represented. The ability to add figures, for example, is extended to the addition of algebraic expressions, of geometric elements such as line segments, angles, and polygons, of directed forces, even of relationships.

Algebraic Abilities: The development of algebraic abilities runs parallel, more or less, to that of the arithmetical abilities. With each new unit new algebraic abilities and skills are formed, and the acquired abilities are made more effective and secure. By gradual steps the various units of instruction provide opportunities for the handling of algebraic manipulations more economically and more efficiently and accurately. As in arithmetical work this requires time and patience. Each unit aims definitely in increasing the rate of performance and in establishing the habit of accuracy.

The algebraic abilities include all the arithmetical abilities and other new abilities which are characteristic of algebraic manipulations. The four fundamental operations are increased to six to include involution and evolution. The solution of equations, the process of evaluation, the process of graphing related and unrelated quantities, the determination of dependence and variation, the expression of relationships, require abilities which are used not only in algebraic work but also in other branches of mathematics.

Geometric Abilities: Certain abilities may rightfully be called geometric in character. Many of these abilities are acquired in connection with constructions, mensuration, loci, methods of logical demonstrations, and analysis. The geometric skills attendant upon the demonstration of geometric truths will accelerate greatly the work in geometry.

Trigonometric Abilities: Acquisition of the skills and special abilities needed in trigonometry need not differ from those of either algebra or geometry. It is evident that the algebraic abilities such as the index representation, logarithms, and solution of equations are of utmost significance in the manipulation of trigonometric functions. Nor are

the geometric abilities to be slighted, for trigonometry is but the geometry of the triangle.

Understandings: The second type of the learning products in mathematics constitutes the adaptation of understanding, that is of reflective thinking. Whenever the rationalization of a mathematical process or the comprehension of a mathematical concept is attempted in a unit of instruction in mathematics the understanding of that process or concept becomes a definite aim of instruction in that unit. However, unlike the acquisition of special abilities and skills, the adaptation of understanding is not to be interpreted as made up as various stages of understanding. The point is very significant and needs clarification. It is quite true that we speak of partial and complete understanding, but what do we exactly mean by these phrases? We may mean by partial understanding, for example, the act of rational thinking devoid of the attendant skills and special abilities in the use of the particular concept or process, while by complete understanding we may mean the act of rational thinking accompanied by the ability to use and apply the process. It is quite evident that both of these interpretations are based upon the assumption that the understanding of the particular principle or process is actually acquired and that they differ only in the consideration of the degrees of the attendant special abilities which may be anything from zero to the standard for that process.

May we illustrate. The solution of an algebraic equation is a definite understanding which involves definite rational thinking. The individual may know for a fact that the solution of the quadratic equation is based upon the theory of factoring the algebraic expression into two linear factors, the solution of which, when equated to zero, yield two values for the variable which are the roots of the quadratic equation. Now he may or may not be able to factor a given quadratic expression in one variable, hence may be able or not able to solve the given quadratic equation. The actual solution of the given quadratic equation is made possible by the ability to factor a quadratic expression, but does not necessarily mean that he understands the theory better. The theory applies to the solution of the cubic equation as well, but it does not necessarily follow that the per-

son who understands the theory can solve a cubic equation. In fact the theory though well understood by every mathematician does not enable the solution of an algebraic equation in one variable of higher degree than the fourth.

Hence we are justified in claiming that the acquisition of the adaptation is a definite learning product which is either acquired or not. The student is brought face to face with a vivid and significant concept in mathematics in a given unit of instruction. The concept is presented and unfolded by the teacher and an attempt is made toward rationalization, that is to enable the class to know what it is, what it means, in a word, to understand it. The concept may have been broken up into its constituent parts, and each part presented and developed as an essential of the unit. Problems are presented in connection with each essential unit-element which are intended to gradually enable the class to acquire the desired adaptation of understanding of the concept through the assimilation of the illustrative and descriptive materials as well as the applications. During the assimilative period, a given student may have formed the adaptation, or he may have failed to acquire it, though he has solved the problems of the unit. At the completion of the unit, the teacher inquires as to whether the concept is understood or not. He cannot say because the student has learned to do three of the four essentials of the unit which were directed toward the understanding of the concept that the concept is $\frac{3}{4}$ or 75% understood. The various elements of the unit are so many steps in the stairway leading to the level of understanding. It is meaningless to say that this particular student is 75% on the level of understanding. Clearly, he is either at the level or not. The adaptation of understanding is a unitary thing, the individual is either in its possession or not; there is no other alternative.

Understandings and Skills: The relation between understanding of a process and the special abilities and skills in the application and use of the process may be interpreted diagramatically as follows (Fig. 1). The heavy horizontal line, parallel to the x-axis may be interpreted to represent the level of understanding, the dotted horizontal line the standard or limit of the attendant ability, while the curve

intersecting the line of understanding but approaching the line of the limit of ability assymptotically may represent the curve of learning. The actual learning of the process is accomplished by the consideration of its applications and uses. The individual learns by doing. The curve of learning may begin at zero, that is there may be no initial skill relating to the process, or it may start at a higher ordinate. Somewhere along the line of learning the level of understanding is reached. The learning may stop there, or may be continued to acquire additional skills until there is no further progress and the individual has gradually approached the limit of his capacity. The line of understanding is variable for different individuals, that is it may be attained with facility or with difficulty, after little effort or after much effort, it may be way below the limit of capacity line or even above it, in which case the individual never attains the level of understanding.

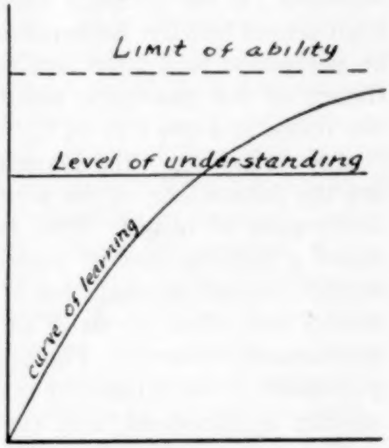

Fig 1

Types of Understandings: As in the case of the special abilities, understandings which are made the definite aims of a unit may be understandings of new concepts or processes, or understandings of old processes with which the student is familiar and which he may be able to use. Many of the processes in which special abilities have been acquired in some units are rationalized later in subsequent units. The division of common fractions, for example, is usually acquired as a special ability, the rationalization of the process is brought about later in the junior high school. The pupil has learned to invert and multiply; why, he is not able to answer. After the process has been rationalized he can answer the question of why he "inverts and multiplies," though he may not be able to manipulate the process with more ease or rapidity. The solution of the quadratic

equation by the formula may be attempted in the junior high school but the rationalization of the process may well be postponed to a later unit in advanced algebra when the theory of the quadratic equation is taught, the nature of the roots, and the role of the discriminant.

Appreciations: The learning products of the third type are the formations of the adaptations of appreciation or of acceptance of values. This type of learning is not always made a definite aim of instruction in the unit of mathematics, though appreciation of the various aspects of mathematics are often stressed as attributes to be acquired in mathematics courses. The appreciation of the methods and processes of the science of mathematics in their relation to specific applications, and the significance of the concepts and principles of mathematics in the world of science, industry and commerce are topics which are much discussed by leaders of mathematical organizations, and the teachers of mathematics are exhorted into rendering a real service to the society by bringing into reality these dominant aspects of the subject. But in spite of the general acceptance of this type of mathematical learning as of real significance and value to the individual and the society, the determination of appreciations as definite aims of instruction has lagged behind that of abilities and understandings, and to that extent real learning is impaired. The difficulty of identifying appreciations as definite aims of units of instruction is due to the fact that the teaching of appreciations of mathematical concepts and processes is not always considered as tangible as the teaching of abilities or understanding. Appreciations being of general character are often grouped with the secondary aims of the unit, and no definite provisions are made for their evaluations at the end of the teaching period. More often the attempts of teaching appreciations and interests in mathematics have been informatory in character, and not earnest endeavors to provide for the formation of the adaptations themselves. Among the various types of tests and scales in mathematics one fails to find any whose aim is to evaluate appreciations. One is led to the obvious conclusion that in spite of our praise of these adaptations we either don't take the matter seriously enough to test for their pressure or else implicitly

assume that their realization is not possible.

Significance of Appreciations: It is generally conceded, however, that interest in the basic concepts of mathematics is of utmost importance to the educated man and woman. By interest is not meant specialization in the subject but rather a sense of acceptance of values of the basic mathematical principles in their true relations to the world of thought and action. They represent the prototypes of mental processes that abound everywhere, the highest mental undertakings of mankind in the conceptual world that has taken thousands of years for some of them to bet developed and advanced to the high plane of their present advancement. Appreciation of the number system for example is appraised in the following statement by Professor Judd:[19]

"He who is master of the number system has a way of thinking that the race has worked out with infinite labor. He will never again fall back into the confused and inexact ways of viewing the world which are characteristic of his childhood. He has grown intellectually by assimilating the number system. He has a mature mind. He has strengthened his mind. He is a new individual."

The appreciations of the basic concepts of mathematics are akin to appreciation of religion, of poetry, of music, and of art. "In speaking of the mission of mathematics," declares Professor Moritz,[20] "I am thinking of mathematics as a spiritual enterprise, which like religion and art ministers to a spiritual need. And as religion has for its chief domain the search for the good and for its mission to minister to the moral needs of man, as art in its quest for the beautiful ministers to the esthetic life, so mathematics in revealing the meaning of truth has ministered and will ever minister to the intellectual life of man."

Appreciation and Understanding: Though closely associated with understanding, appreciation is not dependent upon the adaptation of understanding. For there are appreciations without understandings. Music can be appreciated without being able to play it or understand its technique. The works of art can be appreciated without an understanding of the harmony of colors or proportions of

[19]Judd, Charles H. The Third Yearbook, The National Council of Teachers of Mathematics, p. 10.

[20]Moritz, Robert E. The Scientific Monthly, May, 1928, p. 422.

form. The individual who likes poetry like music has formed the adaptation of appreciation. To accept the values of religious and moral doctrines in human relations and their authority in human conduct and behaviour does not necessarily require an understanding of the science of theology or ethics. Similarly the great concept of function in mathematics can be accepted as a masterpiece of the conceptual realm without being able to understand instantaneous variation or the technique of the calculus. Appreciation of the theory of limits may change the attitude of the individual toward ideals and idealization in life.

On the other hand, appreciation may follow the adaptation of understanding, as understanding may follow the acquisition of special abilities. And this supplementary relation between the adaptations of understanding and appreciation is the key to the solution of our problem in setting up the adaptations of appreciation as definite learning products in the various units of instruction in mathematics. By striving to create appreciation of concepts and principles of mathematics, the instructional materials of the unit brings into play many varied applications of these concepts and principles as means of their rationalization, and if the significance of each concept and each principle in their relations to the problems of life and the world is actually grasped the love and interest for them may readily be created. The appreciation is strengthened in succeeding units by creating new channels of applications and usefulness for mathematical concepts and principles.

FINDS NEW CIRCULATORY SYSTEM IN BRAIN.

A new system of blood circulation in the brain has been discovered by Dr. Gregor Popa and Una Fielding of University College, London.

These investigators find that besides the system by which blood flows from heart to brain and back again, there is a secondary system conveying blood directly from the pituitary gland to the midbrain. This is called a portal system of circulation. The only other such system in the entire body is the portal system between the liver and the intestines.

What part the newly discovered system may play in the distribution of the pituitary hormone, which exercises a powerful effect on the body, has not yet been determined.—*Science Service.*

ANALYSIS OF THE SUBJECT MATTER IN THE EIGHT MOST WIDELY USED TEXTBOOKS IN GENERAL SCIENCE.

By Ira C. Davis,
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There seems to be a general impression that there is a wide variation in the subject matter in the textbooks of general science. Investigations of textbooks by Curtis, Iler and Heineman, Webb, Howe and Weckel, interests investigations by Curtis, Washburne, Pollock, and Finley, and an investigation of the syllabi of several cities by Curtis disclose the fact that there are over 2200 topics mentioned in these different sources. Including a large number of sources does not simplify the problem of selecting subject matter. It only makes it more confusing. It does not necessarily make the choice of subject matter any more accurate.

Any number of topics could be collected for general science without any difficulty. There really is no limit. The question is: What topics are being taught in our schools? These topics may be obtained by determining what textbooks the teachers use, for most of our teachers teach from a textbook. An investigation was conducted to determine what textbooks were being used in the high schools of Wisconsin. It was possible to get this information from reports made to the University of Wisconsin and the State Department of Public Instruction. From the results of this investigation it was found that over 95 per cent of the high schools in Wisconsin use only 7 different textbooks in general science. Investigations, published and unpublished, for other states included an eighth book that was not widely used in Wisconsin. As a general rule the textbooks used in Wisconsin were used in all parts of the United States, with the exception of a few states that used state adopted texts.

It is generally agreed among educators that if a topic occurs in 75 per cent of the textbooks it should be retained as a part of the subject matter offered in that subject. If 95 per cent of the high schools in Wisconsin use only eight textbooks, then the subject matter to be retained should be included in these textbooks. If the material occurs in at least six of the eight books it should be included in the subject matter taught. The topics selected in this way would be taught generally throughout the state of Wisconsin and

would form the minimum essentials of a course in general science. This investigation was conducted to determine what subject matter was included in eight of the most widely used general science textbooks in Wisconsin, and with what frequency this subject matter occurred.

The units in which the subject matter was to be organized was determined by analyzing the contents of the textbooks and by selecting the units that were selected for other investigations by the different investigators. The units selected will be found in the table of results. Such units as transportation, building materials and communication were not used. They are applications of principles found in other units and there is no general use of these units in the different textbooks.

A preliminary investigation of the different textbooks was conducted to determine what topics were to be included at the beginning. The textbook that contained the greatest number of topics was selected as the basis for the investigation of that unit. A topic was retained for any textbook when it contained sufficient material to make that topic teachable. In other words, it would not be necessary to get the necesary information from some outside source. The topics selected were not obtained by consulting the index, but by a careful evaluation of the subject matter offered. In some cases diagrams offered the necessary information. In other cases it was an experiment. If the pupils followed the instructions in the textbook or the experiment, the information would become available through performing the experiment. This method may be open to criticism because the selection of a topic depends on the subjective opinion of the investigator. I believe this method gives just as much accuracy as counting the number of pages or including a topic simply because it occurs in the index. Some editions of all of these textbooks had been used in the writer's classes on a try-out basis. It was not possible to give some of the more recent editions of some of the textbooks a thorough try-out under classroom conditions.

At the completion of the investigation of the first unit in the first textbook, the number of topics to be retained was determined. Other textbooks were analyzed in the same way. If a topic occurred in the second textbook that was

not included in the first it was added to the list. In this way all of the textbooks were analyzed for the topics to be included. It was necessary to re-examine the textbooks to determine whether the topics added as the investigation progressed were to be found in any of the other texts. The topics for the other units were selected in the same manner. At the completion of the investigation it was possible to determine what topics were to be included in each unit, and the number of textbooks in which each topic occurred.

In the final tabulation a topic was retained (with five exceptions) if it occurred in six or more textbooks. This procedure gives a total of 137 topics. Seventy-three topics occur in all of the textbooks, 37 in 7, and 22 in 6. The five topics were retained for five textbooks because there was some doubt whether the topics were treated completely enough. The textbooks were given the benefit of the doubt. If a topic occurred in less than 6 textbooks it was disgarded because it did not occur in 75 per cent of the textbooks.

THE UNITS, THE TOPICS IN EACH UNIT, AND THE NUMBER OF TEXTBOOKS IN WHICH EACH TOPIC OCCURS.

(Investigations based on the latest editions available for use in the school year 1929-30)

Topics	*Number of textbooks in which topic occurs (total of eight)*
Air.	
1. Air occupies space	7
2. Air has weight	8
3. Air exerts a pressure	8
4. Measuring air pressure, barometers	8
5. Ais is compressible—elastic	8
6 Air and fire	8
7. Composition of air—physical & chemical changes	8
	7
Water.	
1 Composition of water	6
2. Water and solution	8
3. Purifying water, boiling, filtering, distilling	8
4. Water pressure	8
5. City water systems—pure water supplies	8
6. Water and soap	8
7. Hard and soft waters, softening hard waters	8
8. Sewage disposal	7
	8
Heat.	
1. Heat, how produced, sun, chemical action, friction, etc.	7
2. Temperature and heat, calories, thermometers	8
3. Expansion of solids, liquids and gases by heat	8
4. Change of state, fusion, vaporization, specific heat	6
5. Distribution of heat, conduction, radiation, convection	8

6. Heating the home	8
7. Methods of starting a fire, matches	8
8. Fuels	7
9. Convection currents—ventilation	8
10. Distillation	7
11. Refrigeration—ice machines—evaporation	8
12. Heating water in the home	8
	12

Weather and Climate.

1. Weather and climate, defined	8
2. Water vapor in the air	8
3. Dew and its formation—dew point	8
4. Clouds—fogs	8
5. Humidity—relative humidity	8
6. Rain, snow, rainfall	8
7. Winds, wind belts	8
8. Storms, cyclones, tornadoes, hurricanes	7
9. The Weather Bureau, weather maps, weather service	6
10. Climate and health	6
11. Effect of water on climate	5
	11

Light.

1. Methods of producing light, luminous objects	8
2. Light travels in straight lines, transparent objects	8
3. Reflection—diffusion, images	8
4. Refraction, lenses	8
5. Color and the prism	7
6. The eye and the camera	8
7. Lighting our homes	8
	7

Sound.

1. How sound is produced	8
2. How sound is transmitted, air—voice	8
3. The ear and how we hear	8
4. Noise and tone, pitch	6
	4

Magnetism and Electricity.

1. History of Magnetism—natural magnets	6
2. Magnets—magnetic fields	8
3. The earth as a magnet—compass	7
4. Static electricity, lightning	8
5. What is electricity—electron	7
6. Units of electricity—volt, ampere, ohm	7
7. Making electricity—chemical action, storage batteries, dynamos	8
8. Series and parallel connections, circuits, grounding	6
9. Magnetic effect of a current—electromagnets	8
10. Chemical effect of a current	5
11. House circuits—fuses, switches, sockets	7
12. Electric meter, electric power	7
13. Electrical appliances—doorbells	8
14. Telegraph	8
15. Telephone	8
16. Radio	6
17. Heating effects of an electrical current	8
18. The electric arc	8
19. The electric motor	8
	19

Energy and Machines.

1.	Energy—definition—forms of	8
2.	Force—work—power, how measured	7
3.	What is a machine, law of machines	8
4.	Lever, pulley, wheel and axle	8
5.	Inclined plane, wedge, screw	7
6.	Friction	8
		6

The Solar System.

1.	The solar system, the sun and its planets	8
2.	The constellations	8
3.	The moon, its phases	8
4.	Eclipses	7
5.	Causes of day and night	5
6.	Causes of the seasons	7
7.	Comets—meteors	6
		7

Rocks and Soils.

1.	How the earth was formed	6
2.	Changing rocks to soil, weathering, freezing, plants, chemicals, gravity	6
3.	Erosion—water, wind, glaciers—tides	7
4.	Classification of rocks, igneous, sedimentary, metamorphic	6
5.	What is soil. Kinds of soil	7
6.	Keeping the soil fertile	6
7.	Tilling the soil	7
8.	Drainage and irrigation	7
9.	Water in the soil	7
10.	Minerals, oils and ores in the earth	6
		10

Plants.

1.	General description, structure of living things	7
2.	Seeds—germination of—kinds of seeds	6
3.	Leaves—kinds, how they breathe, how they make food	8
4.	Stems—how sap rises—buds	7
5.	Roots—how they get food—how moisture rises	7
6.	Flowers—parts—how seeds are formed—how seeds are scattered	7
7.	Reproduction—seeds—stems	7
8.	Bacteria—yeasts and molds	7
9.	Uses of plants for foods	8
10.	Leguminous plants	7
11.	Forests—uses of wood	7
12.	Improving plants	7
13.	Plant diseases	6
		13

Animals.

1.	Birds, bird migration	6
2.	Insects, bees, ants	7
3.	Animal pests, flies, mosquitoes	5
4.	Diseases of animals	5
		4

The Human Body.

1.	Structure of the body	7

2. Digestion	8
3. Breathing and respiration	8
4. Circulation of the blood	8
5. The skin	7
6. The Teeth	8
7. The eyes	8
8. The ear	7
9. First aid	6
	—
	9

Foods.

1. Why we eat foods	8
2. Cooking of foods	8
3. Action of yeast on food	8
4. Why foods spoil, bacteria	8
5. How to keep foods from spoiling	8
6. Molds	8
7. Sources of foods, organic and inorganic	8
8. Food calories—heat value of foods	7
9. Carbohydrates	8
10. Water and mineral matter—ash	8
11. Fats	8
12. Proteins	8
13. Vitamins	8
14. Balanced diets	8
15. Food adulterants	6
16. Stimulants and narcotics	7
	—
	16

Clothing.

1. Sources of fibers, silk, wool, cotton, linen	6
2. Heat conduction properties of the fibers	6
3. Washing clothes	6
4. Cleaning clothes—dry cleaning, removal of stains, bleaching	6
	—
	4

FREQUENCY OF TOPICS IN TEXTBOOKS.

(Of the 7 topics accepted for air, 6 occur in 8 textbooks, and 1 in 7)

Number of textbooks	*8*	*7*	*6*	*5*	*Total number of topics accepted*
Air (Number of topics)	6	1			7
Water	6	1	1		8
Heat	8	3	1		12
Weather & Climate	7	2	1	1	11
Light	6	1			7
Sound	3		1		4
Electricity & Magnetism	10	5	3	1	19
Energy & Machines	4	2			6
Solar System	3	2	1	1	7
Rocks & Soils		5	5		10
Plants	2	9	2		13
Animals		1	1	2	4
Human body	5	3	1		9
Foods	13	2	1		16
Clothing			4		4
Totals	73	37	22	5	137
Per cent of total	53.28	27.01	16.06	3.65	100.00

NUMBER OF TOPICS IN EACH TEXTBOOK.

	Accepted Number	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Air	7	7	7	7	7	6	7	7	7
Water	8	8	7	8	8	7	6	7	8
Heat	12	12	12	11	12	12	11	12	10
Weather & Climate	11	11	9	10	11	11	8	10	10
Light	7	7	7	7	7	7	7	6	7
Sound	4	4	4	3	4	3	4	3	4
Electricity & Magnetism	19	19	19	18	16	15	14	18	17
Energy & Machines	6	6	6	6	5	5	6	6	6
Solar System	7	6	6	5	7	7	5	7	6
Rocks & Soils	10	10	7	9	8	10	10	7	5
Plants	13	13	13	12	13	13	13	4	10
Animals	4	4	4	1	3	4	3	1	3
Human Body	9	9	9	9	9	8	9	8	6
Foods	16	14	16	15	15	16	16	15	16
Clothing	4	4	4	4	2	4	2	2	2
Total	137	134	130	125	127	128	121	113	117

SUMMARY AND CONCLUSION.

There is a high agreement in the textbooks for the units air, water, heat, weather and climate, light, magnetism and electricity, energy and machines, plants, the human body, and foods. There is a fair agreement in the units sound, the solar system, and rocks and soils. Several topics were discarded in these units because they occurred in only a few books. There is very little agreement in the units on animals and clothing. It is questionable whether there is enough aceptable material to retain the units of sound, animals and clothing. Some of the textbooks include sound with air. Some of the textbooks include animals and clothing with the human body or foods.

The 137 topics accepted gives a sufficient number to form the minimum essentials of a course in general science, if not a complete course. It is not argued that these are the only topics to be taught. Neither is it argued that they are the correct topics to teach. They are the topics our teachers are teaching. The continued use of the textbooks containing these topics seems to indicate that they are satisfactory. At least the teachers feel they are producing results.

The results of the investigation demonstrate clearly that our leading textbooks in general science do agree on subject matter. They are no longer a hodge-podge or piecemeal mixture of science. While the agreement in subject matter in general science is not as high as it is in physics, it is higher than it is in biology or chemistry. Of the 137

accepted topics, the least number accepted for any of the textbooks is 113 and the highest is 134. Over 53% of the topics are found in all of the textbooks, 27% in 7, and 16% in 6. Over 96% of the material is found in at least six of the eight books.

The topics accepted are being taught by a large majority of our teachers. The next question is: "Does this subject matter meets the present objectives in the teaching of general science?"

PUPIL INTEREST IN HIGH SCHOOL SUBJECTS OF STUDY.

By A. C. Monahan,
Formerly U. S. Bureau of Education.

A study recently made by Dr. Warren W. Coxe, Director of Research of the New York State Department of Education, and Dr. Ethel L. Connell of the same division, makes available data relative to the subjects in the high school curriculum found to be "most interesting" and "most uninteresting" to high school pupils. Opinions were obtained from about 4,600 high school girls and boys, approximately the same number of each sex. They were asked to state of all the subjects taken by them in their high school course, "which had been especially interesting, and those which had been decidedly uninteresting." A summary of the answers is included in an article by the two people mentioned above, in the March, 1931, number of *New York Education.* The following table is taken from it with the permission of the journal.

Percentage of Pupils Liking and Disliking Subjects.

Subject Groups	Percent Finding Most Interesting			Percent Finding Most Uninteresting		
	Boys	Girls	Total	Boys	Girls	Total
Languages	20.7%	35.6%	28.5%	36.3%	22.1%	28.8%
English	7.8	15.3	11.8	14.1	7.1	10.4
Modern	7.0	11.3	9.3	4.1	2.2	3.1
Ancient	5.9	9.0	7.5	18.1	12.8	15.3
Mathematics	17.2	13.6	15.4	17.3	23.4	20.6
Sciences	27.4	14.5	20.4	6.1	10.2	8.3
Social Sciences	13.6	10.8	12.2	9.0	13.7	11.4
Music—Art	2.4	5.5	4.0	1.4	1.2	1.3
Commercial	7.4	13.3	10.6	2.2	4.8	3.6
Vocational	6.1	4.2	5.0	.5	.4	.5
No preferences	2.5	1.5	2.0	26.6	23.6	25.0
Miscellaneous	2.6	0.9	1.7	.5	.5	.5

These figures are not directly comparable between subjects in the table as the study does not include data relative to the number of students who had taken each of the separate subjects. For instance, the five per cent of the pupils who found the vocational subjects the most interesting is five per cent of the total number of pupils reporting and not merely five per cent of those who had taken vocational subjects. For this reason the figures in the lower half of the table is of little value to the readers of this article; they are given because the figures in the upper half are of great value, and it was thought best to reprint the entire table as given by the writers of the original article.

The figures in the upper half are to a certain degree comparable, as all high school pupils take English in their course, most of them take at least one year of a modern language, practically all take some mathematics, all take one or another of the social sciences, and a considerable per cent take at least one science sometime during their four years in high school. In this respect these subjects in the upper part of the table differ from those in the lower.

Probably the "most interesting" fact for the science teacher in the figures in the table is that while the total number taking a science is undoubtedly *less* than the total number taking languages, mathematics, or the social sciences, the percentage that found the sciences the "most interesting" is *greater* than that for mathematics and the social sciences, and also than for English, or the other languages combined. And again, the sciences were recorded as "most uninteresting" by a considerable *lower* percentage than that for the languages, mathematics, or the social sciences. It ought to be encouraging to science teachers to know that the pupils who elect their subjects find them more interesting than they do other subjects of study, and the fact ought to encourage them to take every legitimate step to get a larger proportion of the total student body enrolled in the sciences than the present number.

At the request of the writer Mr. Coxe submitted to him some data on preferences in the sciences not given in the article in *New York Education*. They are given in the table below. It is interesting to note that biology among the sciences was found to be most often "most interesting"

and also "most uninteresting." It is interesting also to note that no pupils found either physics or chemistry to be the most uninteresting in their course. Boys like the sciences better than the girls do, this is particularly true of physics.

INTEREST IN SCIENCE SUBJECTS.

Subject	Percent Finding Most Interesting			Percent Finding Most Uninteresting		
	Boys	Girls	Total	Boys	Girls	Total
Biology	13.0%	10.0%	11.5%	5.1%	7.6%	6.4%
Chemistry	4.0	1.7	2.9	.0	.0	.0
Physics	5.4	.6	3.0	.0	.0	.0
Other Sciences	5.0	2.0	3.5	1.1	2.5	1.8
Total Science	27.4	14.5	20.4	6.1	10.2	8.3

In the study the students were asked not only to name the subject that they found most interesting and most uninteresting but also to state *why* they found them so. The reasons were grouped by Dr. Coxe and Dr. Cornell under three general heads:

1. Reasons that indicated an *intrinsic* interest or lack of interest in the subject such as "subject seems real or alive" and "dead subject," etc.

2. Reasons that indicated that interest or lack of interest was due to *extrinsic* factors, such as "interest created by teacher," "disliked teacher," etc.

3. Reasons that indicated that interest or lack of interest was due to ability or lack of ability on the part of the pupil to see practical value in the subject.

The following table summarizes the answers. It also was printed in *New York Education.*

WHY SUBJECTS ARE LIKED OR DISLIKED.

	Interesting Subjects		Uninteresting Subjects	
	Boys	Girls	Boys	Girls
Reason 1	38.8%	34.1%	20.7%	25.9%
Reason 2	29.9	33.5	55.6	56.4
Reason 3	36.2	28.3	23.7	17.7

These figures are the most interesting in the study. They are the most valuable for the teacher as they show what a pupil likes and dislikes in a subject of study. It is evident from them that students like subjects that have intrinsic value, and subjects that have practical value that they can see. They dislike "dead" and "dry" subjects, and those in

which they are unable to appreciate the practical value. They appreciate the teacher who makes his course interesting by supplementing the outlined or textbook course with outside material, illustrations, applications, etc.: "Interest created by the teacher" is an excellent phrase.

They say that they found certain subjects uninteresting because they "disliked the teacher." The writer is quite convinced from many years in educational work that there is a close relationship between liking for a teacher and the way the teacher presents his subject to his class. The teacher, even one with what is usually designated as "poor personality," who makes his subject vital and interesting through proper teaching methods and the use of illustrative materials and attention to practical applications, is seldom disliked by pupils. "Poor teachers" are usually disliked. The instructor who says "Pupils do not like me because I make them work" is presenting a "most interesting alibi" if it is true that pupils do not like him. Boys and girls like hard work if it is really interesting.

Science teachers have an advantage over most others in meeting the likes and overcoming the dislikes of the pupils for various subjects. The subjects that they teach have great apparent intrinsic value, and pupils may see with little difficulty their practical applications. Also the instructor has a vast amount of illustrative materials that he can bring in from the outside to make his course interesting. In addition he includes in his course many science demonstrations, attractive in themselves but particularly liked by pupils as most "visual aids in education" are liked. Where the sciences are taught even with a "low degree of efficiency," the teaching must be of a very low degree if any average pupil finds the subject dead or too dry. A science instructor must be a poor teacher indeed if any pupil can ever say of him after taking his course that the subject was the most uninteresting because he "disliked the teacher." Probably it is less often said of science teachers than of others in any of the principal high school courses; at least fewer pupils who had taken sciences had found them "most uninteresting" because of the various reasons given of which "dislike of teachers" is one, according to the above table.

From rather wide experience in visiting schools in all parts of the country the writer is convinced that the majority of high school science teachers who have had sufficient science training for their work, are as efficient as teachers as those of any other subject. The poor science teaching is found more generally in smaller schools where the science subjects are often taught by men or women without science education of sufficient amount and kind to make it probable that they would be successful as science teachers. Also in some of the larger schools it is not uncommon to find science teachers who have settled into ruts and are not keeping up with the newer developments in science, or at least are not making use of them in their teaching. Again one finds high school science teachers who have acquired recent advanced degrees in some science and who for some reason or other is unable to keep their teaching down to the level of the abilities of the pupils. This same difficulty is experienced by many men and women, fresh from their college courses and teaching their first or second year.

The situation in the smaller schools where the sciences are so often taught by persons without science training, is the most serious science teaching problem at the present time. It is not uncommon to find the principal of the school attempting to teach the sciences because he is the only person in the teaching staff that has had any science courses of any kind. This is particularly true in the three and four teacher-high-schools where one man only is employed, usually as principal and then expected to teach the full day at the same time. Another rather common situation is in slightly larger schools where it is felt desirable to have on the teaching staff a man who can coach the athletic teams, but where no money is available to pay a salary as a coach. Such schools frequently engage a man to coach and teach, the sciences being given to him more usually than any other subjects. In all such situations where instructors without sufficient science training are assigned science classes to teach the tendency is to teach a textbook course with little or no individual laboratory work for the pupils and even less teacher-demonstration work.

The remedy for these situations rests with the organized science teachers of a State. They should make the science

section of the State Teachers Association a strong group, able to make itself felt at the State meeting, and to have influence sufficient to reach school principals, superintendents, and boards of education. The State Science Section should encourage the organization of local science associations affiliated with the State Association, and having county and city group meetings several times throughout the school year. Such meetings would do much to encourage individual science teachers to improve their work, but it would also have much influence in creating a sentiment on the part of school authorities against the employment of persons to teach the sciences who have not had proper science training for the work. They should use their influence to see that no high school without a sufficiently trained science teacher is accredited by the state department of education or by the state university. An organized effort on the part of a strong Science Section of the state teachers association has much greater influence than is generally recognized.

"TREASURE TREES" ARE DESCRIBED BY FORESTERS IN NEW BOOKLET.

The story of naval stores, one of the oldest industries in the Southern States, is told in a booklet just issued by the Forest Service, U. S. Department of Agriculture. The Southern States produce about two-thirds of the world's supply of naval stores.

Collection of crude resin from the pines began soon after the first colonies were established in the South. This gum was used for calking ships, whence the name "naval stores," a term which has persisted, though turpentine and rosin are now largely used in scores of other industries. Turpentine is practically indispensable in the paint industry.

Because the southern pines produce dual crops of turpentine and timber, they have been called "treasure trees." In recent years the Forest Service has aided in the introduction of better methods in turpentining operations. The old "boxing" practice, by which a deep hole was cut in the tree to catch the gum, is being superseded by the use of cups and tin gutters. Milder methods of chipping have been shown to be superior both for production and for saving the life of the trees, which, when chipped conservatively and at not too early an age, grow into good timber. Proper turpentining of a "treasure tree" does not appreciably shorten its life, but wasteful and destructive methods of turpentining kill the famous goose that lays the golden egg, says the Forest Service.

Miscellaneous Publication 106-MP, Pine Tree Treasures, may be obtained free from the U. S. Department of Agriculture, Washington, D. C., as long as the supply lasts.

SOME LESSONS ABOUT BEES.

By T. P. Webster, M. A.,
Allegheny Vocational School, N. S., Pittsburgh, Pa.

Lesson V. The Bee As a Craftsman.

Henry Ford in advising young men said that if a young man will spend all his time and money on the best books, the best tools and the best schools till he is forty, the money is bound to come because the result is a superior workman. Some boys do not have the proper attitude toward books and tools. The bee is a very successful worker. In a single summer season a colony of bees often makes three times as much honey as it needs to keep it over winter. If you could earn three times as much money in five or six months as would be necessary for all your expenses for a whole year you would be a very highly paid workman. The bee has many tools on her legs and uses them most deftly. She has a place for everything and everything in its place. This makes for efficiency in production.

Queen

Drone

Worker

The bee in the field is engaged in three extractive industries. The three raw products are pollen or flour for bee bread, propolis or bee varnish, and nectar or sweetened water from flowers, which is the raw material for honey. When pollen is scarce beekeepers often supply the bees with rye flour which they use as a substitute for pollen. An abundant supply of either pollen or rye flour induces the rearing of young bees earlier in the season. Young

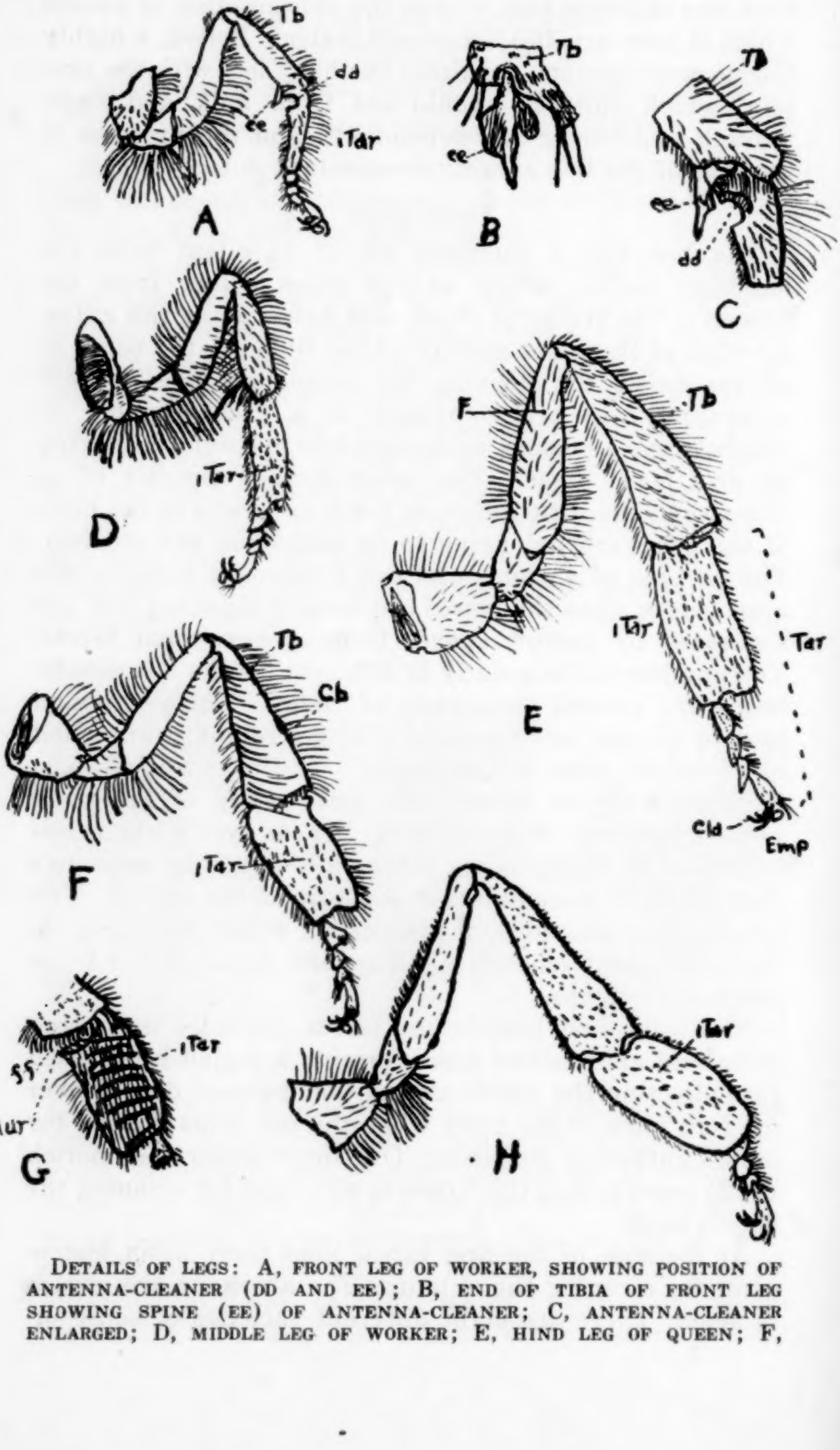
bees like children may overdo the consumption of sweets which if pure are 100% carbohydrates. Pollen, a highly nitrogenous product, furnishes the baby bee with the protein, which children should get from milk and eggs. Growth and repair are dependent upon the proteins in the diet of the bee as well as ourselves.

Front Legs.

The bee has a complete kit of excellent tools for handling pollen, which as you know comes from the flowers. The fringe of short, stiff hairs, along the anterior edge of the inner surface of the tibia (A tb) serve as an eye brush for cleaning the compound eyes. These compound eyes are composed of a great number of separate eye elements, each complete in itself and having its own nerve fiber. The outer surface consists of as many separate little lenses as there are parts in the body of the eye, each belonging to an individual eye element. The surface of a compound eye presents a honey comb appearance since the lenses are usually six-sided and are separated by narrow spaces forming hexagonal facets. The number varies greatly in different insects but usually there are several thousands of them. The compound eyes of the bee are covered by long straight unbranched hairs on the rims of the facets. The eyes appear particularly hairy in young bees since many of the hairs become brushed off in old bees. These eyes without lids to protect them, are being continually poked into nature's flour bins and accumulate much dust on the lenses. The eye brushes placed conveniently on either front leg do the work most efficiently. The bee apparently has no use for eye-drops.

The large first joint of the tarsus (A. itar) is covered with long unbranched hairs forming a pollen brush used for collecting the pollen grains that become dusted over the fore parts of the body when the bee visits flowers for pollen gathering purposes. One investigator (Gennerich 1922) reports that this brush is also used for cleaning the mouth parts.

At the base of the first tarsal joint there is an instrument for cleaning the antenna. The antennae are organs of sense. There are eight different varieties of sense or-



DETAILS OF LEGS: A, FRONT LEG OF WORKER, SHOWING POSITION OF ANTENNA-CLEANER (DD AND EE); B, END OF TIBIA OF FRONT LEG SHOWING SPINE (EE) OF ANTENNA-CLEANER; C, ANTENNA-CLEANER ENLARGED; D, MIDDLE LEG OF WORKER; E, HIND LEG OF QUEEN; F,

HIND LEG OF WORKER, SHOWING POLLEN-BASKET (CB) ON OUTER SURFACE OF TIBIA; G, INNER VIEW OF BASAL JOINT OF HIND TARSUS OF WORKER, SHOWING THE BRUSH OF POLLEN-GATHERING HAIRS; H, HIND LEG OF DRONE. CB, CORBICULUM, OR POLLEN BASKET; CLA, CLAWS; CX, COXA; DD, NOTCH OF ANTENNA-CLEANER ON BASAL JOINT OF FIRST TARSUS; EE, SPINE OF ANTENNA-CLEANER ON DISTAL END OF TIBIA; EMP, EMPODIUM, THE STICKY PAD BETWEEN THE CLAWS FOR WALKING ON SMOOTH SURFACES; F, FEMUR; FF, "WAX SHEARS"; TAR, TARSUS; I TAR, FIRST JOINT OF TARSUS; TB, TIBIA; AUR, AURICLE.

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gans on these antennae. Some of them may be classified as *hair organs, plate organs, pore organs,* etc. Investigators believe that these antennae register impressions of air pressure, closeness of objects in the darkness of the hive, and odor. These delicate organs need constant grooming. The antenna cleaner consists of a deep notch (A, C, dd) in the inner margin of the first tarsal joint fringed with a comb-like row of bristles. The open part of this notch is bridged over with a strong little piece of horny substance (ee) attached to the leg by a hinge. (Shown more enlarged in ventral view at B.) By extending the front leg, placing the notch against the base of the antenna, bending the tarsus toward the tibia and then drawing the antenna backward, the bee is able to clean the antenna of pollen. The tarsus must be moved as the spur (ee) though flexibly attached has no muscles connected with it. The interior of the notch is furnished with a comb, the fine long round teeth of which are close together in a single row all round the half circle (C, dd). The little horny spur (ee) does not carry any teeth but has a sharpened edge which presses the antenna down against the teeth. The eight different varieties of sense organs are by this means kept free of stick substances and the dusty pollen. This comb and scraper device of the bees is placed conveniently on the front legs, one for each antenna and keeps the bees' means of communication in working order with a minimum of time and trouble. You too as a workman must aim always to have your tools in the right place at the right time.

Middle Legs.

The middle legs are less specialized than either the fore or hind legs but the large joint of the tarsus (D, itar) is wide and flat and its hairy surface is used for brushing pollen from the body.

Hind Legs.

On the broad section of the leg (G, itar) on the inside of the leg is the pollen gathering and loading device. Arranged across this section is a series of ten combs similar to the side combs the women used to wear to hold their hair in place. Each comb has its teeth slightly raised from the surface of the legs and partially overlapping the next comb below. These combs being constantly drawn over the bees hairy breast gather the grains of pollen which adhere to the feathered hairs on this part of the bees' body. But more particularly they take pollen from the middle leg brushes and hold it till it is transferred into the pollen basket. The pollen entangled in the hairs of the head is brushed off by the front leg brushes, and is in turn scraped off these front leg brushes and from the hairy middle parts of the body, by the brushes of the middle legs. Much pollen now besmeared with saliva and honey, is by this time on the middle legs. These are now grasped between the hind legs and are drawn forward so that the combs (G, itar) transfer their load to themselves. When the combs are full, the pollen is transferred to the pollen basket on the opposite leg. In this operation the pecten play an important part. The pecten (G ff) is a comb of stiff spines which project downward. The pecten of the right leg scrape the pollen out of the inside combs of the left leg and vice versa. The pollen naturally falls upon the upper surface of the auricle (G, aur). The tarsus (G, itar) is now gently bent backward, pressing the auricle against the sloping end surface of the tibia, compressing the pollen and squeezing it outward upon the outer surface of the tibia (G, tb) and into the lower end of the pollen basket (F, cb). Each new mass of pollen forced through the press pushes the last up a little and sticks to its lower edge. Thus simultaneously the entire mass on each side increases upward, growing from the bottom by the successive addition of transverse layers till at last both pollen baskets (F, cb) contain great balls of compact, gummy pollen spreading to their fringes. Remember our practical mechanic the bee has no use for an inside pocket. The row of curving hairs on each side of the section (F,

tb) clamp down the ball of pollen. This accounts for the wonderful adhesive power of the pellet of pollen as the bee is buffeted about by the stormy winds of March and April.

Now the pollen laden bee goes back to the hive to display her treasure. She wants to say in plain English, "Look what I found." She proceeds to do this by a dancing movement which has been called the "tail wagging dance" to distinguish it from a different dance of the nectar gathers. The dancer describes half circles to the right or left and then goes back to the starting point in a straight line and describes a half circle in the opposite direction. Each time the dancer goes over the diameter of the circle, she makes droll wagging motions of the body. Idle bees crowd closely round the performer and when the dance is finished many of the spectators leave the hive. Here we have the worker urging others to work. There is no such thing as restriction of output. The workers take the maximum advantage of an opportunity to work and help others to find work. The odor of the pollen tells the workers the kind of flower from which it came. They go out to search for it immediately.

The next task is to store it in a cell. After selecting a suitable cell which may or may not be suitable for brood rearing, she grasps the upper edge of the cell mouth with her front feet, rests the tip of her arched abdomen on the opposite rim, protrudes her hind legs into the cell and with the middle tarsi (D, itar) pries loose the pollen balls which drop to the floor of the cell. The labor of delivering the raw product—pollen—is now completed. From here on the work is a refining process so we must hasten on to the next extractive industry of the hive.

Propolis or Bee Varnish.

The bee gets her varnish from the same source as man, the resinous exudation of trees. It is easily obtainable from the sticky bud of the Balm of Gilead tree and in lesser quantity from the buds of popular, horse chestnut, willow and hollyhock. In the absence of a natural supply, the bees frequently resort to paint, varnish, resin, pitch and the like. The superstition that bee follow their owner to the grave after his death probably arose from

seeing the bees at work on the varnish of the coffin.

This varnish is gathered in large quantity in the fall. This it seems is in response to a kind of instinct that bids them prepare for cold weather by filling up the cracks and crevices and cementing the loose parts of the hive together. A swarm going to a hollow tree will clean out all loose particles first and then give a complete coat of varnish to the walls of the cavity. Another unusual use is practiced when it becomes necessary to prevent pollution of the hive by the decay of the body of a mouse or snail that may have crawled into the hive and died. Either of these intruders is too large to be dragged out. The bees have been known to apply layer after layer of propolis to the dead mouse until it is effectively sealed up in an air tight and odor proof coffin of this material. One investigator noticed that the entrance of a dead snail's shell was sealed with propolis to prevent the escape of foul odors. Later other dead snails, which he placed in the hive, were found to be completely covered with the propolis. These shells were cracked so sealing up the entrance only was insufficient. Sometimes small colonies of bees are invaded by the female wax moth which lays her eggs in the hive where they hatch into worms which eat the wax combs. Bees have been known to build propolis and wax pillars in the entrance to the hive contracting it so that the moth cannot enter, but leaving it large enough that the bee is not crowded in going in and out. Here is something in instinct beyond the fixed and unchanging habits of nest building and migration in birds. It is a fine example of successfully arising to an emergency that threatens the welfare of the group. The bee turns embalmer or military engineer when the necessity arises. Dead bees or any other small contaminating objects are always carried out of the hive.

This propolis or bee varnish is the despair of the beekeeper who finds it smeared all over his nice white sections of honey. The propolis spoils the sale of comb honey at a fancy price, and hinders the beekeeper in all the hive manipulations. It covers his hands with a sticky mess which soap and water will not remove. The beekeeper must use turpentime or alcohol to get it off. Lard

applied to the hands before washing with soap and water is a fairly good means of removal. But the bee has none of these to help her remove it from her fuzzy body. She gathers it when it is so warm and sticky that it will draw out as a thread. She applies it wherever needed while it is in a workable state. She can get it off her bristly body without a recipe. She knows how to handle varnish. Her efficiency here is one more important factor in her remarkable success as a producer of marketable goods. She uses the same tools in collecting propolis that she does in collecting pollen.

MAKING GENERAL SCIENCE INTERESTING.

By Nellie M. Jaroleman,
Claremont Junior High School, Oakland, Cal.

The following plan of work has been developed at this Junior High School to create and hold the interest of the pupils of seventh to ninth grades who are in the General Science classes.

I. Laboratory Technique Drill.

This laboratory technique drill is given to each class every semester:

1. Lighting a bunsen burner.
2. Use of a graduate cylinder.
3. Removal of a solid from a reagent bottle.
4. Boiling water in a test tube.
5. Evaporating water.
6. Litmus tests for acids and bases.
7. Filtering a liquid.
8. Using a flask as a generator.
9. Use of a pipette.
10. Weighing.
11. Cleaning of glassware.
12. Use of a mortar and pestle.
13. Use of a thermometer.
14. Care of laboratory table.

This drill was developed in the University High School of the University of California and was published in the University High School Journal, December, 1930. I use it to develop an understanding and skillful use of laboratory apparatus, and to prepare for increased efficiency in all future experiments.

II. Use of Textbooks.

We have thirty to forty copies each of seventeen different textbooks. The books are kept in the science room as a library, and are used by the various classes during the day. Whenever desired, a child may check out a book at the close of school with the understanding that it is to be returned in the morning. In this way we are not confined to any one textbook but are free to select the best sections of various texts. The pupils are afforded an opportunity to form their own judgment in selecting, rather than to blindly follow a single text. References are made as subject matter rather than pages.

III. Work Sheets.

The use of work sheets increases from the seventh to the ninth grade, when a modified form of the Dalton plan is used. These sheets include incomplete statements, experiments, problems, demonstrations, drawings to be labeled, references and spelling lessons. These are all graded and returned, and time is given for discussion either in groups or individually.

IV. Folders.

A large folder is provided for each person in which he files his own papers. This replaces the note book. These folders are kept in the room and are accessible to the pupil and teacher at any time.

V. Large Unit Plans.

At the beginning of each term, the teacher and pupils together develop an outline on the board of their previous work in science; this is followed by a general plan of the work of the present term by the teacher. This serves to show the unity of the work from term to term.

VI. Other Types of Procedure.

1. Vocabulary and spelling drills.
2. Group work.
3. Teacher and pupils' demonstrations.
4. Picture collections.
5. Objective type tests.
6. Use of suitable magazines.
7. Drawings:—reviews by use of drawings on board to illustrate ideas rather than use of words.
8. Some discussion.

9. Exhibits:—for regular work and for special occasions, such as American Education Week.
10. Assembly contributions:—at present we are preparing still-life pictures to show how light aids in developing beauty.
11. Hobby collections:—anyone wishing to do so may have a special table for his collections. For example, two boys brought in unusual nature study collections.
12. Seasonal room collections:—these include wild flowers, garden flowers, leaves, seeds, etc., each one being properly labeled.
13. Outside reading and lectures:—a point system is used for giving credit on outside reading. This is especially effective in the ninth grade. We are unusually fortunate in always having worth while lectures both at the University and in Oakland. Credit is given for attending these. Sometimes a Class attends them together.
14. Outside speakers:—in certain units, these speakers are most helpful. For instance, in the study of communication, the Telephone Company sends out a man to give illustrated lectures. We are particularly fortunate in having Chabot Observatory at our disposal. We not only make day and night trips there for studying astronomy and weather, but Dr. Linsley, a Mills College professor, comes to the school and gives illustrated lectures.
15. Visual Aids:—considerable use is made of slides, still-films, motion pictures, stereographs, etc. All this material is delivered to us from the Oakland Visual Education Center and the Oakland Museum.
16. Animal Care:—such as gold fish, frogs, toads, salamanders, slugs, insects, white rats, occasionally a pet show, baby chicks, garter snakes.
17. Club Meetings:—the ninth grade does some club work in class time. Practically no home work is given. However, it is our ideal to create an interest in outside reading, hobbies, and activities such as relate to the science school work. We are happy in the responses made.

ADDRESS BY THE VICE-PRESIDENT.*

LOUIS A. WENDELSTEIN, *High School, Everett, Mass.*

Mr. President and Fellow Teachers:

The Vice-President is given thirty minutes at the annual meeting to discourse upon any subject that he chooses. It has been the custom for him to talk about his work, and I shall follow that custom, emphasizing those phases of my work that may be different from yours.

Let me tell you a little about Everett High School. It is a comprehensive high school of about 1600 pupils. The curriculum provides a Mechanic Arts Course, Commercial Course, Home Economics Course, College Course, and General Course. As about 25% of the graduating class goes to college, the greater part of our work in science is not college preparatory, primarily.

My work deals with College Preparatory Physics, applied Electricity for Mechanic Arts pupils and Physics for Mechanic Arts pupils. In College Preparatory Physics I adhere to the outline closely and yet I try to diverge enough to stimulate those pupils who, although in the course, will not go to college. I can illustrate this best by taking up my method of teaching Boyles Law.

As part of their assignment, the pupils have acquainted themselves with Boyles work in science. I demonstrate Boyles Law first by connecting a large bottle of air with the faucet and a pressure gauge.

At the beginning of the experiment, the pressure gauge reads 0 lbs. per sq. in. although we know that the absolute pressure is 1 atmosphere or 15 lbs. per sq. in. and the air in the bottle is under this pressure. We start with a bottle full of air. Water is then run into the bottle, and the needle of the gauge moves up indicating an increase in pressure. At this point I stop the experiment to discuss the reason for the increase in pressure, what the absolute pressure is, etc. We continue to admit water until the gauge reads about 15 lbs. per sq. in. We can see that the air in the bottle has been squeezed to half its original volume. A discussion brings out the point that the absolute pressure on the air is twice its original pressure. We then formulate a statement for Boyles Law. Next we discuss the mathematical inferences.

*The 117th meeting of the Eastern Association of Physics Teachers, Mechanic Arts High School, Boston, March 7, 1931.

First, taking the values in the experiment:

$$\frac{1 \text{ vol.}}{.5 \text{ vol.}} = \frac{30 \text{ lbs. / sq. in.}}{15 \text{ lbs. / sq. in.}}$$

Then generalizing with P_1 first pressure
P_2 second pressure
V_1 first volume
V_2 second volume

and we have $$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

I then find it necessary to recall to their minds certain algebraic ideas of proportion. If four quantities are in proportion, they are in proportion by alternation, inversion, composition, etc., and in any proportion the product of the means equals the product of the extremes.

Thus $$\frac{a}{b}=\frac{c}{d};\ \frac{a}{c}=\frac{b}{d};\ \text{etc., or } ad=bc$$

Returning then to $\frac{V_1}{V_2}=\frac{P_2}{P_1}$ we may have $V_1 P_1 = V_2 P_2$ which is what we want.

The students then go into the laboratory, and using the conventional U– form apparatus, proceed to establish this relationship $P_1 V_1 = P_2 V_2 = P_3 V_3$ in terms of cubic centimeters of air and centimeters of mercury pressure. As part of the report they plot the curve, Pressure against Volume. We discuss this curve, why it does not touch either axis and if it did, what is inferred.

We next proceed to analyze problems involving this law, picking out the numerical values of P_1, V_1, P_2 and V_2. Finally we solve the problems, emphasizing the fact that ultimately P_1 and P_2 must be in the same units, and as units we may use lbs. per sq. in., atmospheres, inches of mercury, feet of water, etc., and V_1 and V_2 must be in the same units, and they may be cubic feet, cubic centimeters, liters, etc.

The course in Applied Electricity is given to senior boys in the Mechanic Arts Course. We use Jackson & Black, "Electricity and Magnetism," as the text book, with Delano's, "Applied Electricity," as a laboratory manual, supplemented by many experiments I have devised that are adapted to the equipment we have.

Many of our Mechanic Arts graduates enter the electrical

industries. In order to become acquainted with the industrial methods of manufacture and testing as well as to broaden my own view-point, I have spent a few weeks for several summers, in the development and testing laboratory of the General Electric Company, at West Lynn, Mass. Incidentally, in my work there, I have seen the operation of the Coolidge tube, used to distinguish genuine from synthetic sapphires, (the sapphires are used as jewels in watt-hour meters,) and have observed certain experiments carried out with Carboloy, the new abrasive used for tipping cutting tools.

I shall describe a few experiments that teach electrical principles in perhaps a practical way, if I may use the term, rather than a classical manner. In teaching the principle of D'Arsonval instruments I proceed as follows. I suspend a coil between the poles of a U-magnet, energize the coil with D. C. and we observe that the coil moves. Having previously taken up electro-magnetism, we are able to explain why it moves. Fastening a pointer to the coil graphically, we have a simple galvanometer. As the coil is made of fine wire, such an instrument can measure only small currents, it will have to be altered to measure large currents.

Pupils invariably suggest using larger wire for the moving coil and the objections to this must be pointed out: the weight of the moving element must be kept as small as possible to reduce inertia, reduce torque of springs used, and reduce bearing friction. The only way to adapt this galvanometer to measure high currents is to use a shunt.

The students then go into the laboratory and calibrate shunts for an ordinary Weston Portable Galvanometer. The shunts of such capacities as to allow the instrument to indicate 30, 3, and 1.5 amperes. The Weston galvanometer has practically uniform scale divisions for 0 to 30. The apparatus is connected to the D. C. line with a rheostat, a lamp bank, and a standard ammeter in series with the galvanometer.

In calibrating the 30 amp. shunt, a wide piece of copper sheeting is connected between the binding posts with slots cut in it with shears in order to fit the posts closely. The load is adjusted to 10 amp. and the reading of the galvanometer noted. The deflection is usually 1 or 2 divisions. The circuit is opened, the shunt removed, made smaller by cutting off a strip, replaced, circuit closed, and deflection noted; it has increased. This adjusting is repeated until the deflection on galvanometer is 10

divisions. We now have an ammeter capable of measuring 30 amp. full scale.

For smaller capacity shunts wire of convenient size is used, increasing the length of wire until the proper deflection is obtained; full scale (30 divisions) for 3 amp. shunts and full scale for 1.5 amp. shunts. Lugs are then soldered to the ends of the shunts.

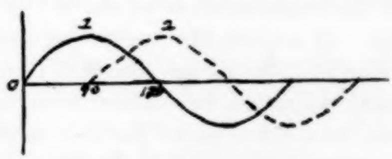
This experiment emphasizes the following points:

1. The principle of multiple range ammeters.
2. The laboratory method of calibrating shunts.
3. The relation between the resistance of a shunt and the carrying capacity of the ammeter.

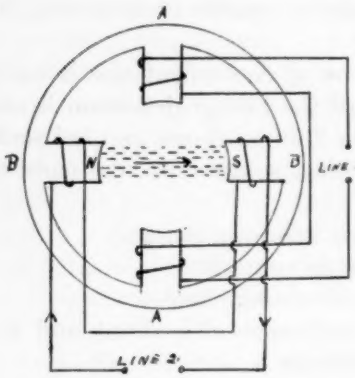
We spend about one-third of the year on alternating currents, and especially the mathematical conceptions in connection with inductance, reactance, power factor.

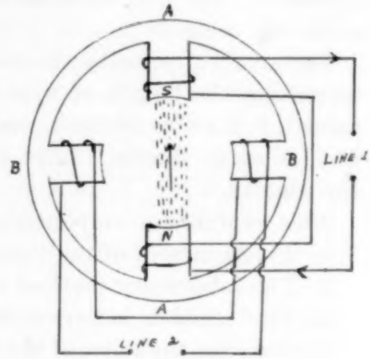
In teaching the principle of the induction watt-hour meter, and the induction motor, I suspend a U magnet over a compass needle and rotate it. The needle of course follows the magnet and rotates. We have a rotating magnetic field, dragging the needle around. Substitute a thin iron strip for the needle, we get the same result.

The production of a rotating magnetic field by means of polyphase currents, must be discussed. We have already taken up phase relationships. Suppose we have two alternating currents at the same frequency, but differing in phase by 90° represented by this curve. These currents are connected to the winding of the stator. It is observed from the curve that when current 1 is maximum, current 2 is minimum, and when current 1 is minimum, current 2 is maximum. When current 1 is maximum, the poles A A are magnetized, with polarity as illustrated. At this instant current 2 is minimum and the poles B B are unmagnetized. The flux direction is shown in the figures.



When current 1 becomes 0 and current 2, maximum, the stator frame is magnetized as shown in figure B. The north pole has moved a quarter revolution in a clockwise direction. Similar diagrams may illustrate the subsequent positions of the N pole





to complete the cycle. Any conductor placed in this field will rotate, and we have the induction motor.

In discussing the single-phase induction watt-hour meter, the phase displacement is produced by placing a high inductance across the line, thus, splitting the single phase into two phases at the meter in order to produce the two phases necessary to give a rotating magnetic field.

With the various parts of a watt-hour meter, a potential coil, current coil, aluminum disk and laminations, these principles can be readily shown.

It is necessary to point out that the passage of alternating flux thru the disk induces in the disk, currents of electricity whose magnetic field reacts with the rotating field, and the effect is to produce a torque.

We are then ready to calibrate a watt-hour meter using laboratory instruments as standards. The apparatus needed consists of a source of current, a lamp bank or other non-inductive load, voltmeter, ammeter, and the watt-hour meter to be calibrated.

The object of the experiment is to check the accuracy of the watt-hour meter. (I adjust the meter beforehand so that it is very fast or slow). The meter constant is recorded, that is, the indicated watt-hours per revolution of disk. By means of a stop watch the time for a given number of revolutions is recorded. This data together with the readings of ammeter and voltmeter, enables us to compare the indicated watt-hours with the true watt-hours.

We can then try the effect of the full load adjustment and readjust the meter to the correct speed.

This experiment points out:

1. The laboratory method of checking a watt-hour meter.
2. How to adjust a meter for non-inductive loads.

The relationship of impedance, resistance, and inductive reactance is taken up in the following manner. The resistance of a coil is measured, on a Wheatstone Bridge, and the pressure in volts across it. We calculate the amount of current that should flow according to Ohm's Law for D. C. circuits. The coil is connected to an A. C. line and the reading of the ammeter noted.

We find that the indicated current is much less than the calculated current which shows that Ohm's Law is not true for A. C. circuits. We apparently have something in our circuit that acts like resistance, we call it inductive reactance, and total effect of the inductive reactance and resistance is called impedance. We have previously discussed inductance and how it produces the back pressure which acts like a resistance. It is now easy to formulate Ohm's Law for A. C. circuits. $I = \frac{E}{Z}$ where Z is impedance. We can next discuss the geometrical relationships of these quantities making use of a right triangle in which the resistance (R) is represented by one leg, the inductive reactance (X_L) by the other leg, the impedance (Z) by the hypotenuse, and θ is the angle between R and Z.

$$Z^2 = R^2 + X_L^2$$
$$Z = \sqrt{R^2 + X_L^2}$$

Since the $\angle\theta$ is the angle of lag and the power factor is $\cos\theta$, we can determine power factor by this formula $\cos\theta = \frac{R}{Z}$ This opens up a discussion of power in A. C. circuits, and by means of curves it can be shown that $P = I\ E$ only when I and E are in phase, and that $P = E\ I \cos\theta$ when I and E are out of phase.

In a vector diagram, let I_f represent the effective current lagging $\theta°$ behind the voltage. This current may be considered as being composed of two components I_R and I_x—component I_R in phase with the voltage and I_x at right angles to the voltage.

Now the average power in the circuit is equal to the effective voltage times the component of the current in phase with the voltage. Thus power $= E_f\ I_R$

From trigonometry $I_R = I_f \cos\theta$

then Power $= E_f\ I_f \cos\theta$

Another simple way of determining power factor is to connect an ammeter, voltmeter, and watt-meter to an inductance, and record the indications. The product of amperes and volts gives apparent power (volt-amperes), and the watt meter gives true power (watts).

$$\text{Then: Power Factor} = \frac{\text{True Power}}{\text{Apparent power}} = \cos \theta,$$

and from trigonometric tables θ may be found.

The principle of the thermo-couple and the pyrometer can be shown by twisting a piece of iron wire and a piece of copper wire together and connecting the ends to a galvanometer. If the junction is heated, a deflection is produced in the galvanometer due to the thermoelectric effect.

If a closely fitting white cardboard scale is put over the metal scale, and the junction immersed first in ice water, and then in boiling water, these points marked on the scale, we have a simple Centigrade pyrometer. Higher temperature points may be located by immersing the junction in boiling oils, and checking the points with a high range mercury thermometer.

In the presentation of material in Physics, given to Sophomores in the Mechanic Arts Course, we confine all measurements to the common, familiar, English system. The student acquires his knowledge in terms of weights and measures with which he is familiar, and with which he will make his applications in every day life.

It is much more effective to present an unfamiliar subject in familiar units than it is to present an unknown subject in unknown units.

We use large masses of material, and simple apparatus on a large scale, in the laboratory, because we find that the students are readily convinced of facts and laws evolved in units that are easily perceived. For example: In lever experiments the pupils use 2 in. x 4 in. studs, 10-15 ft. long for the lever, and masses of iron 10-40 lbs. for weights. All weighing is done on a platform scales which has capacity of 200 lbs. In determining Heat of Vaporization, we use about 15 lbs. of water in a large iron pail, insulating the pail with several thicknesses of asbestos on the outside. Steam is passed into the water in the ordinary manner, from a small boiler. We pass in steam until ¼-½ lb. has condensed. Repeated experiments give an average of about 1030 B. T. U.'s per pound of steam condensed as against 972 B. T. U.

THE TEACHING OF PHYSICS IN ENGLISH SCHOOLS.*

By Mr. Spencer R. Humby, M. C., M. A.
Winchester College, England.

I propose this morning to attempt to sketch in outline the general conditions affecting Physics Teaching in England and then to describe in greater detail the work done in a particular school.

Schools in England bear names which are somewhat misleading to American ears, the words "Preparatory School" and "Public School" having different meanings on the two sides of the Atlantic.

English Schools are divided into two main groups, the Primary Schools taking children up to the age of 14 and the Secondary Schools having pupils from 12 to 16, with advanced classes for those who go on to the Universities at 18.

The Primary Schools consist mainly of 20,000 "Public Elementary Schools" taking over 5 million pupils. Their cost is provided mainly from rates and taxes although about half of them were built originally by voluntary funds collected by members of the various Churches. Attendance is compulsory for all children except those of parents who prefer to pay the fees of the relatively small number of privately owned "Preparatory Schools."

The Secondary Schools are divided into some 300 "Public Schools" many of which are very ancient foundations of great prestige, and 1,500 Municipal or County Secondary Schools mostly founded in the past 30 years and supported by public funds.

In the "Public Schools" are about 60,000 pupils of whom a considerable proportion remain at school till 18½. In the grant earning secondary schools are 400,000 pupils, the majority taking a 4 year course 12 to 16, and some 10,000 staying to take 2-year "Advanced Courses" and leaving at 18 or 18½.

Science Teaching in the Schools.

In the Primary Schools science teaching appears only incidentally as part of Physical Geography or of Nature Study.

*An address delivered at the 117th meeting of the Eastern Association of Physics Teachers, Mechanic Arts High School, Boston, March 7, 1931.

There are two stages in the work of the Secondary Schools. The first is defined roughly by the requirements of the School Certificate Examination, taken annually in 5 or more subjects by 60,000 children at the age of 16. The Examination has a syllabus and a standard generally resembling that of the College Entrance Examination in America. During the 4 years secondary course the pupils divide their time fairly equally among the various subjects without specialising and the syllabus usually includes science during the last three years. Chemistry and Physics are allotted 2 or 3 periods a week each but in some schools only one science is studied and in girls' schools Botany usually displaces Physics.

During the second stage the pupil is allowed to specialize to a limited extent after passing in the S. C. Examination and between ½ and ⅔ of the total school time is allotted to the chosen group of subjects of the advanced course. The group, "Mathematics and Science" is chosen by about half of those who stay on till 18 in the grant earning schools. These students are tested by the Higher Certificate Examination set in July by the University Examining Boards. It demands a high standard of attainment and those pupils who specially distinguish themselves are awarded valuable scholarships to the Universities. There are also Entrance Scholarship Examinations of an even higher standard set at the Universities in December or March.

Qualifications of Science Teachers.

Science teachers in English secondary schools have usually taken at their Universities a degree in Science which has required 3 or 4 years work at the University almost entirely devoted to two or three branches of science with the necessary mathematical courses. Teachers of the advanced courses have generally taken degrees with first or second class honors.

Organizations Which Influence Science Teaching.

There are two associations which influence considerably the actual teaching of science in English Schools. The British Association for the Advancement of Science founded in 1831, holds a week of meetings in different

cities in August or early September and has sections devoted to all branches of science and an education section. The Association forms Committees to undertake special investigations during the year and the reports on educational subjects are usually of considerable interest to teachers.

The Science Masters' Association, founded in 1900, enables science masters to meet and discuss matters of common interest. It holds in January a 4 day conference at which are given demonstrations by teachers who have developed new ideas in teaching and there are exhibitions of books and apparatus by all the leading firms.

The School Science Review issues quarterly reports these meetings, comments on all new tendencies in science teaching and publishes reviews of books and valuable articles on scientific subjects. Various pamphlets issued at intervals by committees appointed by the Board of Education have also a considerable effect on the methods of teaching science. In particular should be mentioned the report of Prime Minister's Committee on the Position of Natural Science in English Education, published in 1918. This report contained many important recommendations. It suggested that Natural Science should be included in the general course of education of all pupils up to the age of 16; that some study of plant and animal life should be included besides Chemistry and Physics and that more attention should be directed to the objects and experiences of everyday life. For students taking the advanced courses, it recommended that those taking science should continue some literary study and should acquire a reading knowledge of French and German, while those specializing in literary subjects should give some time to science work of an appropriate kind. There are many very interesting detailed suggestions in the report concerning these courses in science for the older pupils whose interests lie in language and literature.

Teaching Methods in Physics.

There is at present a good deal of experimentation among physics teachers in English schools. We can divide the methods roughly into three classes which for

convenience may be called academic, heuristic and individual.

The majority probably teach along the lines in which they learned their subject. They combine recitations with laboratory work, selecting the experiments to illustrate those parts of the subject which they feel give special difficulty to beginners. They usually take one or two school terms for each division of Physics. In schools where the timetable allows only a minimum of time for the subject it is not unusual to find some sections of physics neglected in favour of others which the particular master considers more important or more profitable in an examination. This is possible in the School Certificate examination because the papers give sufficient choice of questions for candidates to do well by answering questions from two of the three sections of the paper, usually Mechanics and Hydrostatics, Heat and Light, and Electricity and Magnetism.

In recent years there has been some criticism of the methods of teaching and of the content of the Physics course on the grounds that all pupils should be given a general course in science with an introduction to Astronomy, Geology, and Biology, as well as Physics and Chemistry. The introduction of such a schedule as a subject in the S. C. Examination has so far attracted only 1200 candidates of the 50,000 who enter for science subjects. Some of those who have tried the new course are however enthusiastic in favour of "General Science" and say that it does not produce the superficiality which is an obvious possibility. The more thoughtful of its opponents say that the good teacher makes contacts with all sciences as he is teaching any one subject and that the poor teacher will be even less efficient in General Science than he is now in teaching the one or two subjects he is supposed to know.

Accommodation and Equipment.

The accommodation and equipment available for Physics teaching in the different schools naturally varies very much. In the average small state-aided secondary school there will probably be one class room with lecture bench for demonstrations, and one laboratory. In

the more wealthy schools there is often accommodation and equipment which will excite the envy of University Professors.

In all but the smallest schools, the Physics laboratory has a small workshop and often there is a laboratory assistant who has had some workshop training and can make and repair the simpler forms of apparatus.

Many schools have Science Societies which develop the interests of individuals mainly in the direction of Natural History, Photography and Radio. There are usually school libraries containing science books for reference and for general reading.

PHYSICS COURSES IN A PUBLIC SCHOOL.

It will I hope, be of interest to you if I now go on to talk more in detail of the teaching of Physics at Winchester College.

Winchester is the oldest of the Public Schools of England. There are 450 boys, all boarders, who enter at 13 years of age and stay until 18 or 19 when about 70% go on to Oxford or Cambridge. The general curriculum of the school is still mainly classical as befits a society which has a continuous history from the date of its foundation by William of Wykeham in 1382. The work of the school has however been gradually rearranged so that now every boy takes a 4-year course in science. Those boys who are taking the ordinary classical course spend three periods a week in science. Any who wish to do more science can transfer to a science division after their first or second year in the school; then they can take in successive years 3, 8, 8 and 10 periods for science classes.

We think that every boy ought to have an opportunity to know something of the scientific advances which distinguish the age in which we live, and something of the meaning of scientific method, with training in observation, in the selection of relevant facts and in deduction from them. As boys change considerably in their outlook during the four years the method of treatment must be arranged to suit their developing capacities and interests. At first the boy easily grasps facts, gradually he acquires the power to master methods and theories and

towards the end of the course he is ready to correlate his science with other subjects and develop a power of generalization.

We are well equipped with rooms and apparatus. There are 6 science masters, and the Science School has for Physics two combined laboratory-lecture rooms, one large lecture room and one separate laboratory. There is a similar allotment for Chemistry and two Biological lecture rooms and a laboratory.

The first year of the science course is devoted to hydrostatics and heat, the work being kept as near to everyday problems as possible. The work in the laboratory is designed to develop skill in handling apparatus and in making reasonably accurate observations and measurements.

At the beginning of the second year the boys who wish to do more science are placed in special sections as they do 4 periods of Physics and 4 of Chemistry while the general school course has but 3 hours which are, for that year, used for Chemistry.

Both scientists and classics if we may so call them, do the same schedule in Chemistry, except that the scientists have time for additional exercises of the more quantitative sort.

The work of the Autumn term is made "heuristic." Much time is spent in the laboratory and the facts of combustion and chemical combination are doled out sparingly so that all the emphasis may be concentrated on the discovery of facts rather than their accumulation. The second term is intended to lead up to the conception of atoms and their combination and the third term work introduces some of the more important aspects of Chemistry in its connections with everyday life. Meanwhile in Physics the scientists have been taking a course designed to give a thorough grounding in optics and in magnetism and electricity. The principles of common appliances are constantly referred to but no attempt is made in class to give details. We want the boy to understand thoroughly and exactly how the simple forms of apparatus work and to drive home the corresponding theory. At the same time he is getting experience of

simple arithmetical calculations which will give him a sense of the size of things and the ability to forecast probable quantitative results.

At the end of this year most boys have obtained a School Certificate and so have qualified to enter the University if later they wish to do so. As Mathematics is an alternative subject to a Science in this examination and appears to be easier we are not compelled to hurry our work to cover the Examining Board's syllabus. A certain number add a science credit to their certificate a year later.

The third year for classical boys is given to Physics. These boys do not have to take any external examination in their science and so we have been free to plan our course as we wished.

During the first term we take up Sound and Light. In Sound we lead up to the ear and the voice, and to musical instruments, attempting to show how theory has been developed to explain the facts and how theory has reacted upon invention. This gives an introduction to wave-motion and frequency of vibration. We can therefore begin Light with the idea that differences of colour are due to a different type of oscillatory disturbance to which the eye happens to be sensitive. We then discuss what happens to light when it is scattered, reflected from plane and curved mirrors and refracted through prisms and lenses. This brings us to instruments and to the eye and we finish with the spectroscope and something about the information it gives us about the nature and state of materials in the stars.

Then follows a term of Electricity and Magnetism with laboratory measurements made wherever possible with direct reading multi-range ammeters and voltmeters. The multipliers of these can be made in the school workshop at very small cost. The schedule ends with emphasis on the importance of the conversion of energy into various forms.

The summer term is used for a survey of the discoveries of the past 50 years concerning the nature of electricity and the structure of the atom. The work is illustrated by slides and by demonstrations. It commences

with electrical discharges through gases and the rays which were discovered during the investigation of these phenomena. This leads to the atom and to two or three talks on the principles of radio and so to heat and molecular movements. This gives an opportunity to introduce some demonstrations on diffusion, on the passage of liquids through membranes and on surface tension effects with their intimate connection with reactions in living organisms.

Meanwhile the "scientists" have been taking up more detailed work in physical optics, electricity and heat, using textbooks of the type of Kimball's College Physics or Saunders' recent "Survey of Physics for College Students."

The last year of the general course is intended to bring the classically trained boy in contact with new ideas. There is no individual laboratory work but lectures are fully illustrated by demonstrations, slides and projected book illustrations.

During the autumn term we consider something of the nature of scientific methods of investigation as they have developed from the early philosophies of the Greeks, through Copernicus and Galileo, to the great age of Newton. Then we turn to the discoveries made by Faraday and to those of Pasteur and his successors with their effects on public health and on population.

For the final two terms there is a course in Biology. The first term is concerned with animals as physical chemical mechanisms which behave and which reproduce their kind; the second treats of the theories of evolution and of heredity and of the modern uses of this knowledge in plant and animal breeding.

The 4th year of the "scientists'" course is devoted to advanced heat (kinetic theory and the laws of thermodynamics), some wave motion (with elementary interference and diffraction) and the properties of materials (moments of inertia, the constant of gravitation and more advanced hydrostatics).

This prepares the best boys for University Entrance Scholarships at Oxford and Cambridge for which they sit in the December of their 5th year after a term of re-

view and conference work. They have finally two terms free before going to the University. They generally work in the laboratories at problems in which they are specially interested, attend the two term biology course and spend time in improving their knowledge of French and German.

PRELIMINARY TESTS AS PROGNOSTIC OF FINAL ACHIEVEMENT IN PHYSICS.

BY A. W. HURD,
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In matching students for educational experimentation, it is important to use as data for matching those which correlate highly with final achievement ratings. For example if matching is done on a basis of mental age, in order to be valid, achievement should correlate highly with mental age. If factors other than mental age are more determinative of the achievement under consideration, it is certainly not wise to use mental age as a sole basis for matching. Ideal matching is matching on the basis of all factors which contribute to achievement. If these factors were properly weighted and expressed in scaled units of measurement, the combined indices of achievement obtained would correlate perfectly with achievement ratings. This implies that the achievement ratings are perfect measures of achievement.

Such ideal conditions are never obtained largely because of inconsistency. Even though all factors determining achievement were known and scales constructed for their accurate measurement, the human organism is so variable and inconsistent that the individual variability in itself enters as an unevaluated factor. Motives to activity are particularly variable in given individuals. About the only way of caring for this factor is to so arrange contrasted groups of pupils in large enough numbers, so that it may be assumed that variability in motive in one group balances that in the other. As a matter of fact, random sampling involving all factors is probably as good a method of matching as can be found. It is only because of the necessity of working with small groups

that we attempt to match groups, so that we may be fairly certain that conclusions drawn from experimental data are not in serious error.

In matching individuals for educational experiments, the criteria most valuable are those correlating most highly with desired achievement. Intelligence ratings are most common. Previous scholastic records are probably as good if not better. The preliminary test has possibilities. All in all, the correlations reported in this article show that under usual conditions, a preliminary test covering the identical material is superior to any other single criterion now used. It is actually the nearest single criterion most likely to be related to achievement. Table I presents a list of correlations obtained between pre-tests and final identical tests measuring the desired and planned achievements. The tests are unit tests in physics having average reliability coefficients of about .91±.01.

TABLE I—COEFFICIENTS OF CORRELATION BETWEEN PRELIMINARY AND FINAL TESTS IN PHYSICS.

Unit*	Coefficients	P. E.	Cases	Unit	Coefficients	P. E.	Cases
II	.88	.01	98	XI	.52	.07	45
	.29	.12	27	XII	.69	.09	14
III	.73	.04	59	XV	.56	.05	79
	.65	.06	58		.69	.05	41
	.76	.03	117		.19	.06	100
IV	.75	.03	82	XVI	.66	.06	33
V	.54	.09	32		.89	.02	38
VI	.29	.08	65		.10	.07	105
VII	.54	.07	47		.32	.09	52
VIII	.71	.08	21		.06	.07	102
IX	.59	.04	104	XVII	.10	.07	100
	.81	.04	40				
	.51	.06	61				
	.80	.04	50				

*For unit titles see Work-Test Book in Physics by A. W. Hurd, MacMillan, 1930.

The mean coefficient is .54. It is peculiar, however, that most of the low coefficients were obtained from one school. Omitting these coefficients, the mean coefficient is .63. This still includes some relatively low ones from other schools. All coefficients were obtained from 11th or 12th year classes in the secondary school. It is evident

that in general, they are higher than the general run of correlations between intelligence and achievement ratings or between achievement ratings and any other criteria commonly reported. In other words, in general, the preliminary test covering identical subject material is the best single criterion of final achievement. Therefore, it is the best single criterion for matching pupils for educational experimentation. Palpably, if pupils are matched as well in several other criteria, so much the better. Suggested bases of matching are sex, grade in school, chronological age, previous school records, mental test scores, and preliminary test scores.

It is apparent that in one school to which reference is made in the preceding paragraph, preliminary test scores have little relationship to final scores. Why are there such low correlations as reported from this one school? It is obvious that some very potent factors of measured achievement have been resorted to which have produced an array of achievement ratings in an order not corresponding to preliminary test ratings, nor indeed to any other criteria available. Correlations in the same school between achievement and mental ratings (probable learning rate) for three unit tests are $.04 \pm .07$, $.10 \pm .07$, and $\pm .034 \pm .07$ for approximately 100 pupils in each case.

What procedures might produce such conditions? The following are possibilities: (1) coaching of pupils on specific test items, (2) flagrant cheating on tests, (3) definite concentration on the learning of the specific concepts of the units which are covered in the tests, (4) definite remedial teaching to make sure that each individual has mastered the concepts of the unit. It is evident that if specific concepts are selected as objectives of a unit of instruction, and specific plans are made and carried out to insure mastery by every student, there will be a general level of attainment by all, and correlations with suspected preliminary prognostic criteria of future achievement will be zero. This pre-supposes that the definite objectives are possible of achievement by all pupils in the group, in the allotted time.

Is it not reasonable to contend that the objectives of any unit of instruction shall be within the capacities of

every pupil who is allowed to enroll for the course? The writer believes that this should be true of what may be called *minimal essentials.* Individual projects in curricular or extra-curricular activities should be the form in which specialized individual capacities may find full opportunity for development. In cases where objectives are so inclusive that they cannot be attained by any pupil, preliminary tests are the best single criterion of future achievement, provided that no coaching on test items takes place and cheating is not wide-spread. Experimentation may be expected to clarify any divergencies of opinion in this matter.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Mo.

SPECIAL NOTICE.

After June 1, address all correspondence to G. H. Jamison, Teachers College, Kirksville, Mo. Mr. Jamison will be the Editor of this department beginning with the October, 1931, issue.

LATE SOLUTIONS.

1142. *Albert Schwartz, Perth Amboy, N. J.*
1158. *Joseph L. Stearn, College of the City of New York.*
1159. *Hyman Laden, Philadelphia, Pa.*

SOLUTIONS OF PROBLEMS.

Editor. Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no india-ink figure given.

1163. *Proposed by E. C. Kennedy, University of Texas.*

$$(\sqrt{X+2}+1)^{(\sqrt{X+2}+1)}=43.5$$

Solved by W. E. Baltzer, Battle Creek, Mich.

Let $\sqrt{X+2}+1=Y$; then $Y^y=43.5$.

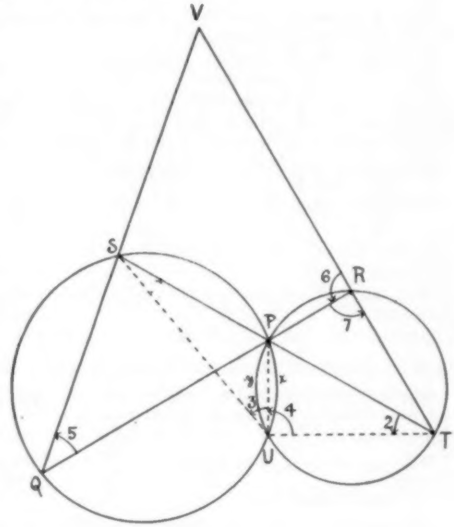
Hence, $Y \log Y=\log 43.5=1.63849$.

By inspection $3<Y<4$, and by methods of approximation, $Y=3.2234^-$. Then $X+2=2.2234^-$; $X+2=4.9435^-$; and $X=2.9435^-$.

Also solved by *Louis R. Chase, Newport, R. I.; W. E. Buker, Leetsdale, Pa.;* and the *Proposer.*

1164. *Proposed by W. E. Baltzer, Battle Creek, Mich.*

Two circles intersect at P; QPR and SPT are two variable lines terminated by the first circle at Q and S and by the second circle at R and T. Prove that QS and RT intersect at a constant angle.



Solved by Louis R. Chase, Newport, R. I.

Angle 1 is constant, being measured by ½ arc x.

Angle 2 is constant, being measured by ½ arc y.

Therefore angle 3 + angle 4, constituting the remaining angle of triangle SUT, is constant. (1)

Now, angle 5 = angle 3, each being measured by ½ arc SP.

Also, angle 6 = angle 4, each being supplementary to angle 7. (Opposite angles of an inscribed quadrilateral are supplementary.)

Substituting in (1), angle 5 + angle 6 is constant.

Therefore angle V, the remaining angle of triangle QRV, is constant.

Also solved by *Charles A. Tepper, Roosevelt H. S., Chicago, Ill.; R. T. McGregor, Elk Grove, Calif.; Emma Estelle Gassiot, Livingston, Texas; W. E. Buker, Leetsdale, Pa.;* and the *Proposer.*

1165. *Proposed by E. B. Escott, Oak Park, Ill.*

Solve the equations:

$$X^2 - YZ = A \qquad (1)$$
$$Y^2 - XZ = B \qquad (2)$$
$$Z^2 - XY = C \qquad (3)$$

Solved by Bert Norbert, Trinity H. S., Chicago, Ill.

Let $Y = VX$ and $Z = UX$. Substituting these values in the given equations, and solving, we get:

$$X^2 = \frac{A}{1 - UV} = \frac{B}{V^2 - U} = \frac{C}{U^2 - V} \qquad (4)$$

Solving the equations in (4) for U and V, we get:

$$U = 1 \text{ or } U = \frac{C^2 - AB}{A^2 - BC}, \qquad V = 1 \text{ or } V = \frac{B^2 - AC}{A^2 - BC}.$$

Substituting these values of U and V in (4), we get

$$X = \frac{\pm(A^2 - BC)}{\sqrt{A^3 + B^3 + C^3 - 3ABC}}.$$

The numerator for the value of Y is $\pm(B^2 - AC)$, and the numerator for Z is $\pm(C^2 - AB)$.

Also solved by *Louis R. R. Chase, Newport, R. I.; H. G. Ayre, Waukegan, Ill.; M. Freed, Wilmington, Calif.; B. M. Lindemuth, Defiance, Ohio;* and the *Proposer.*

1166. *Proposed by Douglas Bates, Portland, Oregon.*

Editor. See March issue, page 349, for the reading of this problem, and the accompanying figure.

Mr. W. E. Baltzer, Battle Creek, Mich., sent in values for X = 31.9′, Y = 54.8′, and "delta" = 83°56′. No work was given, showing how these results were found.

1167. *Proposed by Albert Schwartz, Perth Amboy, N. J.*

Find a number N so that when unity is added to it and to its half, both results give integral squares.

Solved by W. E. Buker, Leetsdale, Pa.

Since $N/2+1$ is an integer, N is even.

Now, since $N+1=x^2$ where x is an integer, and N is even, x^2 must be a number whose unit's digit is 1, 3, 5, 7, or 9. But no square ends in 3 or 7; so x^2 ends in 1, 5, or 9. And N ends in 0, 4, or 8.

Reference to a table of squares gives the following values of N:

$N=48$; $N+1=49=7^2$; $N/2+1=25=5^2$

$N=1680$; $N+1=1681=41^2$; $N/2+1=841=29^2$

$N=57120$; $N+1=57121=239^2$; $N/2+1=28561=169^2$

Other values could probably be found by a continuation of the above method.

Also solved by *Sam Kendrick, University of Kentucky; Louis R. Chase, Newport, R. I.; B. M. Lindemuth, Defiance, Ohio; Hazel Estelle Fliess, Clifton Forge, Va.; W. E. Baltzer, Battle Creek, Mich.;* and the *Proposer.*

1168. *Proposed by Leslie Hunt, Harvey, Ill.*

Some time ago I saw a silver tea set in a dealer's window. The following cost marks and retail prices were given:

Sugar bowl	hkhc	$ 6.72	Creamer	hckh	$ 6.00
Tray	amsl	50.16	Teapot	siab	91.08
Tongs	hblt	1.72	Spoons	hmit	10.52
		Complete	blcsk	$166.20	

Assuming the profit was the same in each case, what per cent was realized? What was the cost mark?

Hazel Estelle Fliess, Clifton Forge, Va.

The cost marks for the sugar bowl and the creamer give a clue as to the value of h. It is not difficult to find that the word "blacksmith" is the key to the number marks. h = 0.

The cost of the complete set is $124.65. The profit (margin) is $41.55, which is $33\frac{1}{3}\%$ of the cost, or 25% of the selling price.

Also solved by *Walter C. Pribnow, Sparta H. S., Wis.; Adsum, Lewis Institute, Chicago, Ill.; W. E. Baltzer, Battle Creek, Mich.; W. E. Buker, Leetsdale, Pa.; Louis R. Chase, Newport, R. I.;* and the *Proposer.*

PROBLEMS FOR SOLUTION.

1181. *Proposed by George Sergent, Tampico, Mexico.*

Four numbers are in geometrical progression; their sum is 50, and the sum of their squares is 5125. Find the numbers.

1182. *Proposed by W. E. Baltzer, Battle Creek. Mich.*

I is the incenter of a triangle ABC. The tangent at any point K on the incircle is met by perpendiculars through I to IA, IB, IC, at P, Q, R, respectively. Prove that AP, BQ, and CR are concurrent.

1183. *Proposed by Norman Anning, University of Michigan.*

Examine the function F(X) = Xth root of X for maxima, minima and points of inflection. (X greater than zero.) Sketch the graph of F(X).

1184. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

Construct a triangle given the magnitude of one angle and the positions of the orthocenter and the center of the nine-point circle.

1185. *Proposed by Sudler Bamberger, Harrisburg, Pa.*

A rope one-half inch in diameter is coiled about a point in an even layer. Its end is four feet from the point. How much rope is in the coil?

1186. *Proposed by George Sergent, Tampico, Mexico.*

Given the two non-parallel sides and the diagonals of a trapezoid, show how to compute the area.

A VOCATIONAL SCIENCE CLUB.

By Mabel Spencer,
Granite City, Ill.

The activities of a club must be different, they must be worthwhile, interesting, and accomplishable to attract the modern high school boy. Membership in any organization may become an educational recreation or a boresome duty, but most of all the program of a science club may appeal to those instincts and attitudes most suited to the teen aged boy who delights in going places and doing things.

Active membership, in our club, the Vocational Science Club of Granite City, Illinois, is limited to forty. Each boy must give some very definite service to the club in order to continue his membership. Every opportunity is given him to display some ability already developed and to develop other worth-while abilities. We attempt to develop his scientific and social horizon, to give him interests which may be carried over into his future recreations, and to establish in his mind the belief that life holds much of promise for the clean, intelligent, and enthusiastic worker.

The activities of our club are greatly facilitated by the efficient and whole hearted co-operation of Mr. Harold B. Diemer, director of Vocational Education, and his entire faculty. Our unusual industrial location and our nearness to St. Louis make our educational trips of great value and not too expensive.

Our science club specializes in interesting trips. During the past year we have visited in St. Louis: The Bell Telephone Company, the St. Louis Post-Dispatch, the Gradwohl Technical Laboratories, the Auto Show, and the Washington University Engineers' Open House. In our own community we have seen: the St. Louis Coke and Iron Company, the American Steel Company, Swift's Meat Packing Plant, an ice company, and the Laclede Steel Company at Alton. Most of the trips were made on the students own time and attendance was optional. A discussion of what was to be seen before taking the trip has been found a decided advantage in helping the boys understand what was seen. Unselfishness

in club activities must be fostered if the best interests of the boy and school are to be maintained. On most of our trips other pupils of the department were invited to go with us.

Well-rounded club activity requires some educational impetus. We have found that each student has some unusual ability or hobby, about which he likes to talk and to which other members enjoy listening. Our outstanding programs of student production included: an illustrated lecture on explosives by a student who worked at the Western Cartridge Company; a lesson on how to make the various types of candy was given by the son of a confectioner, after which we all made candy; a talk on a trip to England was made by a boy whose early childhood was spent in England; and talks on the various sciences were made by boys who were being taken into the club. Our club quartet is one of our "finest" accomplishments and helps add variety and enthusiasm to many of our meetings.

Outside talent is brought to our club and much interest is maintained in this way. Two very interesting programs of this type were presented this year. One was a First Aid Program given by a troop of Boy Scouts who had become especially proficient at this work. The other program was an illustrated lecture on "The Science of Photo-engraving" given by Mr. F. H. Decker, vice-president of the Harrison Company Engravers of St. Louis. Through the combined efforts of our city librarian and our club, Dr. A. E. Bostwick, famous Science Editor of the Literary Digest, came to our city and delivered a public lecture on "Making Science Popular."

The club must take some part in civic activities if it is to be worthwhile, help to further an interest in the contributions of Science. Our club has helped with relief work. We sponsored distribution of food to the needy at Thanksgiving time, decorated the goal posts for a charity football game, and our quartet sang at a Charity Benefit Show sponsored by one of our local theatres.

There are few organizations which can contribute more to the general well being of a school than an active

science club. We have sponsored safety days, architectural and scientific displays, and a poster contest; and we have contributed to every edition of our high school paper. Our members have been active as class officers, stage managers, and art editors. We managed the lunch stand for the summer school students and published a mimeographed summer school paper every two weeks. We won first prize in an all high school gift shop contest with our gift, which was a memory book with the senior ring insignia on it. We award each semester, an honorary four year membership in our science club to the beginning freshman having the highest scholastic average in our department.

The social life of the club has been varied and inexpensive. Among the most interesting events have been our initiations, our Faculty-Parents Nights, and our exchange parties with the girls' Home Economics Club. We have had parties for various festive occasions such as Christmas, Hallowe'en, and St. Patrick's. A treasure hunt, a chili supper, a swimming party, a boat excursion, and a hay ride are included in our list of social affairs. Our motto is "Never repeat the same general type of entertainment." Something different is more interesting and educational.

Our civic, school, and social activities have led us to believe that the wider the range of activities of the club the greater the benefits derived by its members. Affiliation with the Illinois Junior Academy of Science has been an inspiration to us to have a worthwhile club. Thirteen members attended the 1930 meeting held at the University of Illinois, and several of our boys went to Peoria this May. Our contributions to the Junior Academy have included: an academy emblem which was awarded as first prize for the best group of posters at the 1930 meeting, an edition of the Junior Academy Newsletter, and a Science Week program.

The activities of our eighteen months old club are merely suggestive, any civic or school undertaking offers opportunities to a science club for timely and interesting performance. A science club's success may be judged only by its service to its members, and community. Would you enjoy being a member of your Science Club?

GEOMETRIC APPLICATIONS OF COMPLEX NUMBERS.

BY ALLEN A. SHAW,

University of Arizona, Tucson, Ariz.

Introduction. Two excellent papers have appeared recently in the American Mathematical Monthly[1] on the use of the complex variable to elementary geometric proofs. The first paper is by Professor L. L. Smail who uses the complex number in its two-dimensional from, $x+iy$; the second paper is by Professor S. A. Schelkunoff who prefers the use of the single symbol z.

Before writing these lines, the present writer read through the exercises on the complex variable in a large number of text books on college algebra and was surprised not to find even a single exercise of the type recommended and worked out by Professors Smail and Schelkunoff! This general conservatism plainly indicates that it is high time we had some change in the type of exercises in the algebra of complex numbers for the immediate as well as the future interest of the student. For common experience of freshman teachers shows that the average student looks upon the imaginaries with a certain amount of fear and suspicion, and there is reason for this: he does not find sufficiently convincing applications in the traditional exercises of his text book. We have not offered him *immediate* applications of the complex variable as we have done in the case of reals. The student naturally wants to use the imaginaries in the proofs of the mathematics *he already knows,* in the demonstrations of elementary plane geometry, for instance, as well as in the proofs of the plane analytical geometry in the next semester. These advantages we have denied him. The beginner has not been and cannot be satisfied by a very *remote* promise by the teacher that he (the beginner) will find in later years the applications of imaginaries in higher physics, conformal mapping, electrical engineering problems, etc. Such a method of teaching the subject is, no doubt, unpedagogical and will not, therefore, create interest in the subject. Let us make the imaginaries a constant tool in the solution of problems of elementary plane geometry and of elementary plane analytics[2] and we will see the difference.

It is not therefore, an exaggeration to say that the two papers

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[1]Smail, Lloyd L., Some geometric applications of complex numbers, American Mathematical Monthly, vol. 36 (1929), pp. 504-511.

Schelkunoff, S. A., A note on geometrical applications of complex numbers, American Mathematical Monthly, vol. 37 (1930), pp. 301-303.

[2]See *the American Mathematical Monthly* for an excellent article by Prof. G. A. Bingley on the complex variable in the solution of problems in elementary analytical geometry, vol 33 (1926), pp. 418:421.

cited above should be considered as epoch-making in the elementary geometry as well as in the algebra of complex numbers for future text books. No doubt there are other teachers who like Smail, Schelkunoff and Bingley have had the experience of applying the complex variable to prove geometric theorems as illustrations, but as they were the first who brought such applications before the public, the credit is theirs as well as the honor.

It is the purpose of this paper to recommend a free use of *both* methods of approach according to convenience, giving preference to the single symbol z whenever possible, as it certainly affords, in general, simpler and more elegant proofs as Professor Schelkunoff rightly remarks. We also supply solutions by imaginaries of a few additional theorems and make use, in some of them, other properties of the complex variable (see the list of formulas on page 3.) As mentioned above, it is hardly necessary to point out that papers on geometric applications of complex numbers have the double advantage of encouraging the beginner in his study of the algebra of complex numbers in the freshman year more intelligently and, at the same time, preparing him for the study of Function Theory and its applications to physics and electrical engineering problems in later years.

Throughout this article complex numbers corresponding to points or vertices A, B, C, D, etc. of a triangle or quadrilateral, in reference to some origin O, are z_1, z_2, z_3, z_4, etc. written in brackets adjacent to the capitol letter as shown in each figure.

In this paper we shall make use of the following simple formulas:

The distance from the point P_1 (z_1) *to the point* P_2 (z_2) *is given by*

$$(1) \quad P_1P_2 = z_2 - z_1.$$

The point P (z) *which divides in a given ratio* r *the stroke from* z_1 *to* z_2 *is given by*

$$(2) \quad z = \frac{z_1 + rz_2}{1+r},$$

where r is real.

When $r=1$ we have, as a special case, *the mid-point formula:*

$$(2') \quad z = \tfrac{1}{2}(z_1 + z_2)$$

When $r=2$, we have *the trisection-point formula:*

$$(2'') \quad z = \tfrac{1}{3}(z_1 + 2z_2)$$

(3) kz and z, $k(z_1 \pm z_2)$ and $(z_1 \pm z_2)$, $kz_1 z_2$ and $z_1 z_2$, $k\dfrac{z_1}{z_2}$ *and* $\dfrac{z_1}{z_2}$,

all represent parallel vectors in pairs. In each pair the lengths are in the ratio k : 1.

(4) If $|z_1+z_2+ \dots +z_n| = |z_1|+|z_2|+ \dots +|z_n|$, the *z's must all have the same amplitude.*

(5) *The two lines joining the points z_1, z_2 and z_3, z_4 will be*

(i) *perpendicular if*

$$\text{am}\left(\frac{z_1-z_2}{z_3-z_4}\right)=\pm\frac{\pi}{2}$$

i.e. if
$$R\left(\frac{z_1-z_2}{z_3-z_4}\right)=0^3, \text{ (purely imaginary)}$$

(ii) *parallel if*

$$\text{am}\left(\frac{z_1-z_2}{z_3-z_4}\right)=0 \text{ or } \pm\pi$$

i.e. if
$$I\left(\frac{z_1-z_2}{z_3-z_4}\right)=0^3, \text{ (purely real)}$$

Theorem 1: *The lines joining the mid-points of the sides of a triangle ABC divide the triangle into four equal triangles.*

Proof: Consider the quadrilateral ADEF. By formula (1), we have

$AD=\frac{1}{2}(z_2-z_1)$
$FE=\frac{1}{2}(z_2-z_1)$

$\therefore$ AD and FE are equal and parallel, by formula (3).

$\therefore$ ADEF is a parallelogram.

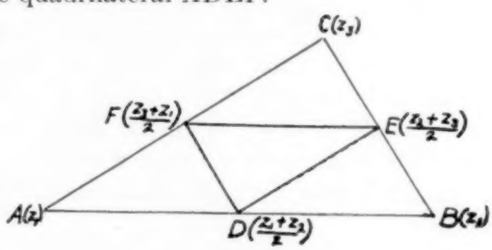


FIG. 1

Hence the diagonal DF divides this parallelogram into two equal triangles, i.e. $\triangle$ ADF = $\triangle$ DEF.

Similarly,

$$DF=\tfrac{1}{2}(z_3-z_2) \text{ and } EC=\tfrac{1}{2}(z_3-z_2).$$

$\therefore$ DF and EC are equal and parallel. Hence DECF is a parallelogram, consequently, $\triangle$ DEF = $\triangle$ ECF.

Similarly, FDBE is a parallelogram. For $DB=\frac{1}{2}(z_2-z_1)=FE$.

$$\therefore \triangle DEF = \triangle DFA = \triangle ECF = \triangle BED.$$

Theorem 2: *Prove that the triangle formed by joining the three mid-points of the three sides of an isosceles traingle is isosceles.*

[3]If $z=x+iy$, then the real part of z is written $R(z)$ and the imaginary part of z, $I(z)$, to represent x and y respectively.

Proof: In Fig. 2, AC = BC. Consider the quadrilateral AFDE. By formula (1), we have
$AF = \frac{1}{2}(z_2 - z_1)$ and $ED = \frac{1}{2}(z_2 - z_1)$.
$\therefore$ AF and ED are equal and parallel and the quadrilateral is a parallelogram.

Similarly, FBDE and FDCE are parallelograms.

$$\therefore FE = BD = DC = \tfrac{1}{2}s$$
$$\therefore DF = CE = EA = \tfrac{1}{2}s$$

where s is one of the equal sides of $\triangle$ ABC.

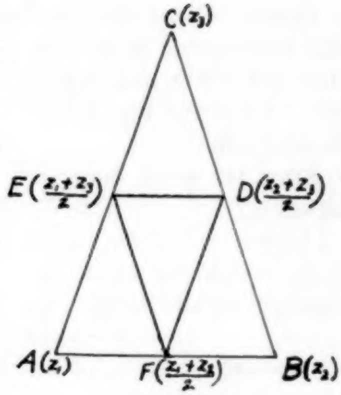


FIG. 2

Therefore, FE = FD and the triangle is isosceles.

Theorem 3: *The medians of a triangle meet in a point which is two thirds of the distance from each vertex to the middle of the opposide side.*[4]

Proof: Let P (z_4) be the point of trisection, two-thirds of the distance from A to D, in Fig. 3, and let Q (z_5) and R (z_6) be the corresponding points on BE and CF respectively. Then by formula (2), we have

$$z_4 = \tfrac{1}{3}\left(2.\frac{z_2+z_3}{2} + z_1\right)$$
$$= \tfrac{1}{3}(z_1 + z_2 + z_3),$$

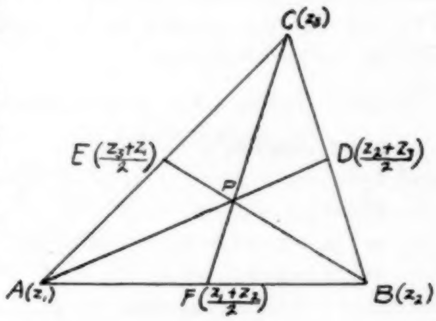


FIG. 3

$$z_5 = \tfrac{1}{3}\left(2.\frac{z_1+z_3}{2} + z_2\right) = \tfrac{1}{3}(z_1 + z_2 + z_3),$$

$$z_6 = \tfrac{1}{3}\left(2.\frac{z_1+z_2}{2} + z_3\right) = \tfrac{1}{3}(z_1 + z_2 + z_3).$$

Since $z_4 = z_5 = z_6$, the points P, Q and R coincide, and the theorem follows.

Theorem 4: *If the diagonals of a quadilateral bisect each other, the figure is a parallelogram.*

[4]This and Theorem 6 are proved by Prof. Smail in his paper quoted above, using the complex variable in the two dimensional form, x+iy as he does throughout the paper.

Proof: Given AC and BD intersecting at E such that BE = ED and AE = EC. To prove Fig. 4 is a parallelogram.

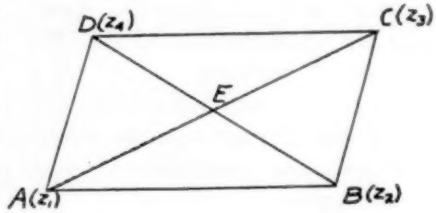


FIG. 4

From the given data we have

$\frac{1}{2}(z_1+z_3)=\frac{1}{2}(z_2+z_4)$ (1)

from which we have, by transposing and simplifying (1),

$$z_2-z_1=z_3-z_4. \qquad (2).$$

(2) shows that sides AB and DC are equal and parallel, hence the theorem is proved.

Note that from (2), or (1), we have

$$z_4-z_1=z_3-z_2 \qquad (3)$$

which shows that AD and BC also are equal and parallel, incidentally proving another property of a parallelogram.

Theorem 5: ABCD *is a parallelogram,* E, F, G, H, *are the mid-points of the sides* AB, BC, CD, DA *respectively. Prove that* EG *and* FH *are parallel to* BC *and* CD *respectively, and that* EFGH *is a parallelogram.*

Proof: (i) Since Fig. 5 is a parallelogram,

$z_2-z_1=z_3-z_4$ (1)

and $z_4-z_1=z_3-z_2$ (2).

$\text{EG}=\frac{1}{2}(z_3+z_4-z_1-z_2)$

$=\frac{1}{2}(z_4-z_1+z_3-z_2)$

$=\frac{1}{2}(z_3-z_2+z_3-z_2)$, from (2),

$=z_3-z_2=\text{BC}$.

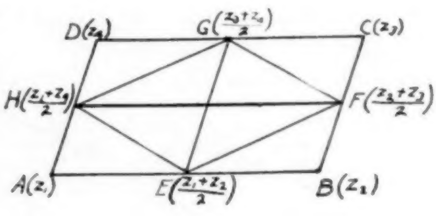


FIG. 5

∴ EG is equal and parallel to BC.

$\text{HF}=\frac{1}{2}(z_2+z_3-z_1-z_4)$

$=\frac{1}{2}(z_2-z_1+z_3-z_4)$

$=\frac{1}{2}(z_3-z_4+z_3-z_4)$, from (1),

$=z_3-z_4=\text{DC}$.

∴ HF is equal and parallel to DC.

(ii). Consider the quadrilateral EFGH.

$\text{EF}=\frac{1}{2}(z_3-z_1)$ and $\text{HG}=\frac{1}{2}(z_3-z_1)$.

∴ EF and GH are equal and parallel, hence the figure is a parallelogram.

Theorem 6: *If a line is parallel to the base of a triangle and*

bisects one side, it bisects the other side also.

Proof: Place the triangle as shown in Fig. 6. If $\left|x+yi-\frac{b+b'i}{2}\right|$ is parallel to $|a|$, then, by formula (5),

$$\mathrm{I}\left(\frac{2x+2yi-b-b'i}{a}\right)=0,$$

or $\mathrm{I}\,[2x-b+i(2y-b')]\div a=0.$

i. e. $2y-b'=0,$

$$\therefore b'=2y.$$

$\therefore$ D bisects AB[5]

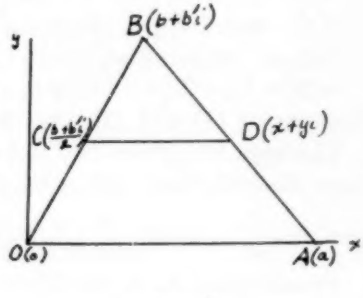


FIG. 6

Theorem 7: Prove that the median of a trapezoid is parallel to the bases, and is equal to half the sum of the bases.

Proof: By formula (2), the mid-points of AD and BC are immediately found and shown as in Fig. 7. Given DC parallel to AB. $AB=z_2-z_1$ and $DC=z_3-z_4$.

$\therefore AB+DC=z_2-z_1+z_3-z_4$.

$=z_2-z_1+z_3-z_4$, by formula (3),

$=z_2+z_3-z_1-z_4=2EF.$

Hence the theorem follows.

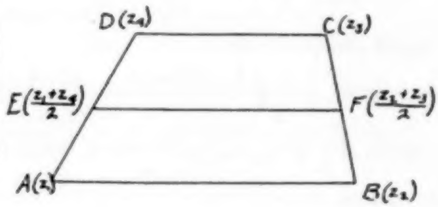


FIG. 7

Theorem 8: *The sum of the squares of the sides of a quadrilateral is equal to the sum of the squares of its diagonals plus four times the square of the segment joining the mid-points of the diagonals.*

Proof: From Fig. 8, by formula (1), we have $AB^2+BC^2+CD^2+DA^2$

$=(z_2-z_1)^2+(z_3-z_2)^2+(z_4-z_3)^2+(z_1-z_4)^2$

$=2z_1^2+2z_2^2+2z_3^2+2z_4^2-2z_1z_2-2z_2z_3-2z_3z_4-2z_4z_1.$ (1)

Similarly,

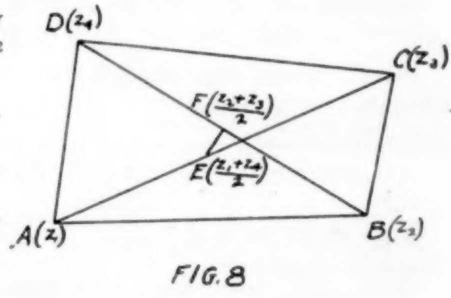


FIG. 8

[5]Since the right triangles BOA and BCD are similar.

$AC^2+BD^2+4FE^2$

$$=(z_3-z_1)^2+(z_4-z_2)^2+4\cdot\tfrac{1}{4}(z_2+z_4-z_1-z_3)^2$$
$$=z_3^2-2z_1z_3+z_1^2+z_4^2-2z_2z_4+z_2^2+z_2^2+z_4^2+z_1^2+z_3^2$$
$$+2z_2z_4-2z_1z_2-2z_2z_3-2z_4z_1-2z_4z_3+2z_1z_3$$
$$=2z_1^2+2z_2^2+2z_3^2+2z_4^2-2z_1z_2-2z_2z_3-2z_3z_4-2z_4z_1. \quad (2)$$

Comparing (1) and (2), the theorem is proved.

Theorem 9: *Prove that a point can be found which is at the same distance from each of the four points*

$$(am_1+i\frac{a}{m_1}),\ (am_2+i\frac{a}{m_2}),\ (am_3+i\frac{a}{m_3})\ \text{and}\ (\frac{a}{m_1m_2m_3}+iam_1m_2m_3).$$

Proof: Let A, B, C, D be the four points. If the point $x+iy$ be equidistant from A and D, then we have

$$x+iy-(am_1+\frac{ia}{m_1})=x+iy-(\frac{a}{m_1m_2m_3}+iam_1m_2m_3)$$

$$\therefore (x-am_1)^2+(y-\frac{a}{m_1})^2=(x-\frac{a}{m_1m_2m_3})^2+(y-am_1m_2m_3)^2$$

which simplifies into

$$x-ym_2m_3=\frac{a}{2}\left(\frac{1+m_1^2m_2m_3-m_2^2m_3^2-m_1^2m_2^3m_3^3}{m_1m_2m_3}\right). \quad (1)$$

Again, if $x+iy$ be equidistant from B and D, we have similarly

$$x-ym_3m_1=\frac{a}{2}\left(\frac{1+m_1m_2^2m_3-m_3^2m_1-m_1^3m_2^2m_3^3}{m_1m_2m_3}\right). \quad (2)$$

Solving (1) and (2), we have

$$x=\frac{a}{2}\left(m_1+m_2+m_3+\frac{1}{m_1m_2m_3}\right),$$
$$y=\frac{a}{2}\left(\frac{1}{m_1}+\frac{1}{m_2}+\frac{1}{m_3}+m_1m_2m_3\right).$$

This point, $x+iy$, is equidistant from A, B, D, and symmetry shows that this same point is equidistant also from B, C, D. Consequently, it is equidistant from the four given points.

Theorem 10: *If* G *be the centroid in the triangle* ABC, *prove that* $AB^2+BC^2+CA^2=3\ (GA^2+GB^2+GC^2)$.

Proof: From Fig. 10, by formula (1), we have

$AB^2+BC^2+CA^2$

$$=(z_2-z_1)^2+(z_3-z_2)^2+(z_1-z_3)^2$$
$$=z_2^2-2z_1z_2+z_1^2+z_3^2-2z_2z_3+z_2^2+z_1^2-2z_1z_3+z_3^2$$
$$=2(z_1^2+z_2^2+z_3^2-z_1z_2-z_2z_3-z_3z_1). \quad (1)$$

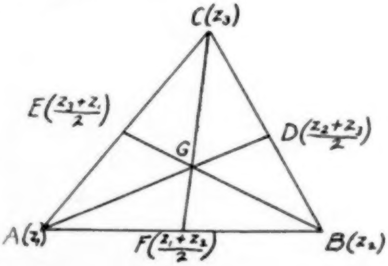


FIG. 10

$3(GA^2+GB^2+GC^2)$

$$=3\left\{\left(z_1-\frac{z_1+z_2+z_3}{3}\right)^2+\left(z_2-\frac{z_1+z_2+z_3}{3}\right)^2+\left(z_3-\frac{z_1+z_2+z_3}{3}\right)^2\right\}$$
$$=\tfrac{1}{3}\left\{(2z_1-z_2-z_3)^2+(2z_2-z_1-z_3)^2+(2z_3-z_1-z_2)^2\right\}$$
$$=\tfrac{1}{3}(4z_1^2+z_2^2+z_3^2-4z_1z_2-4z_1z_3+2z_2z_3+4z_2^2+z_1^2+z_3^2-4z_1z_2-4z_2z_3+$$
$$2z_1z_3+4z_3^2+z_1^2+z_2^2-4z_1z_3-4z_2z_3+2z_1z_2)$$
$$=\tfrac{1}{3}\left\{6(z_1^2+z_2^2+z_3^2-z_1z_2-z_2z_3-z_3z_1)\right\}$$
$$=2(z_1^2+z_2^2+z_3^2-z_1z_2-z_2z_3-z_3z_1). \qquad (2)$$

Comparing (1) and (2) the theorem follows.

SCIENCE QUESTIONS.

A Column of Co-operation in a Magazine of Co-operation.

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Co-operation is the **process** of **Give and Take.** What can you give? What would you like to take? Please help to make this a real **Department of Co-operation.**

EXAMINATION PAPERS ACKNOWLEDGMENT.

True-false Test in Physics from George P. Unseld, West High School, Salt Lake City, Utah.

Tests in Physics and Chemistry—M. Ginat, Professeur de Physique au Lycée du Havre, France.

Term and Quarterly Examinations in Biology and Botany—Franklin R. Myers, Public Schools of the Township of Bernards, Bernardsville, N. J.

Mid-years in Science, Biology, Chemistry, Commercial Science, Physics, Wm. F. Rice, Jamaica Plain High School, Jamaica Plain, Boston, Mass.

HIGHRITER'S TESTS IN FRENCH.

SCHOOL SCIENCE AND MATHEMATICS published these tests in the following numbers: June, 1929, page 649; March, 1930, page 444; May, 1930, page 575.

These tests were published (translated into French) in the May, 1930, number of L'ENSEIGNEMENT SCIENTIFIQUE. A comparison of results in graphical form between these tests and regular French examinations is published in the June, 1930, number of the same journal.

Through the courtesy of Professor M. Ginat, the Editor (Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio) has a dozen copies of the latter number which he will gladly mail to interested readers.

LETTER FROM PROFESSOR GINAT.

Concerning the experiment of giving Highriter's Tests to French students at the Lycée, Havre, France. *Translation French to English by Robert Skidmore, Shaw High School and Cleveland College, Cleveland, Ohio.*

Dear Sir:

I have read with great pleasure your letter of February 18th, and I thank you for the interest which you have taken in my pedagogical experiment. You will find herewith all the papers which you asked for: 1st, the copy of L'ENSEIGNEMENT SCIENTIFIQUE (May, 1930), in which was published the translation of the electricity test from your journal (SCHOOL SCIENCE AND MATHEMATICS); 2nd, the copy

(in duplicate) of the composition *(Composition);* 3rd, the copy of the text of the actual test *(Epreuve d° examen).*

These three exercises are different enough, as you will be able to see. There are nevertheless some analogous standards: it was proposed in the three cases to test the knowledge and the aptitude of the students. I wanted to show you exactly the use we make of the last two exercises. The problems are proposed, less for the purpose of obtaining from the student a numerically exact answer, than to judge his aptitude to attack a question and to conduct his reasoning and his judgment. The reasoning out of the solution is as important as the results of calculation. We appreciate particularly a solution where all the calculations are explained and indicated arithmetically; where the laws made use of are recalled; where the results, even intermediate, are neatly put down; where the student tries to judge in bringing back the given problem to some actual experiences, and where the reasoning leaves nothing lacking in clearness, precision, brevity. In the same way, the question of the course of the actual test ought to be something besides a recitation. The student puts forth, a propos of the given subject, the knowledge acquired in class. It is up to him to put his ideas in order, to present them according to a logical plan, which brings to light the thoughts or the essential facts.

I have indicated in italics on one of the copies, for the *"composition"* and *test* ("Examen") the numerical coefficients credited to the different parts of the exercise.

It goes without saying that I remain entirely at your service if any other information interests you.

Your excellent tests are beginning to spread through France. Several colleagues have utilized your journal. I am attaching to this letter some tests in physics, chemistry, and even in mathematics, which will prove to you all the interest which we take in your teaching research. They have been tried in the Lycée of the Havre, since October, 1930. They are at present making some experiments on the subject of these tests, the results of which will appear in L'ENSEIGNEMENT SCIENTIFIQUE *(The Teaching of Science).*

On my part, will you let me ask a question? Have you, in America, any collections of tests? If you have, I should be very grateful to you if you will give me the name of one of these works.

Accept Mr. Jones, my best wishes.

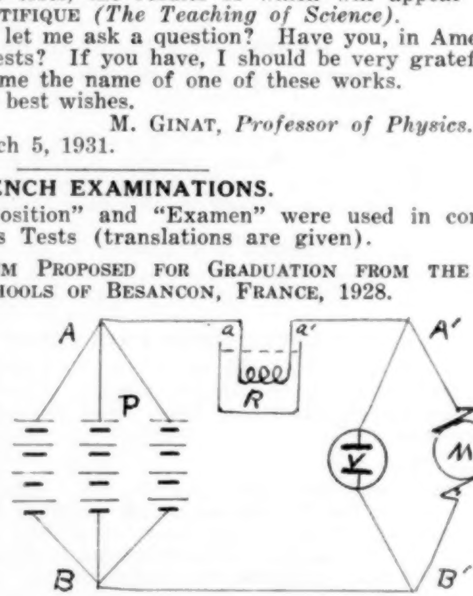
M. GINAT, *Professor of Physics.*

Le Havre, France, March 5, 1931.

FRENCH EXAMINATIONS.

The following "Composition" and "Examen" were used in comparison with Highriter's Tests (translations are given).

COMPOSITION: PROBLEM PROPOSED FOR GRADUATION FROM THE SECONDARY SCHOOLS OF BESANCON, FRANCE, 1928.



A circuit composed of a battery P of 12 similar cells, a resistance R, and two branches between points A' and B': the one A'VB' contains a voltameter of acidulated water, the other A'MB' a small motor.

1. The battery is arranged in 3 series groups of 4 cells each; the electromotive force

of each cell is 2 volts and the resistance is 0.3 ohm. Compute the electromotive force and the resistance of the battery. *(4 points)*

2. R is a coil of ferro-nickel wire of resistivity $\rho = 78.5$ microhms /cm, one meter long and one mm in diameter. Compute the resistance. ($\pi = 3.14$.) *(2 points)*

3. The coil is immersed in 400 g of oil of specific heat 0.5; the temperature of the oil is increased 1.2° in 4 minutes 10 sec. What is the current intensity through the coil? *(4 points)*

4. The connecting wires Aa, a'A' and BB' have negligible resistance. Compute the difference of potential between points A' and B'. *(2 points)*

5. The voltameter V has a back electromotive force of 1.4 volts and the resistance of the branch A'VB' (including the voltameter) is 3.8 ohms. What volume of oxygen measured under normal conditions will be liberated in 16 minutes 5 seconds? (96500 coulombs liberate 1 g of hydrogen, which has a volume of 11.2 liters.) *(4 points)*

6. The resistance of the motor M is 1.2 ohms, that of the connections A'M and B'M is negligible; compute the counter electromotive force and the power of the small motor. *(4 points)*

EXAMINATION IN PHYSICS FOR GRADUATION IN THE SECONDARY SCHOOLS OF CAEN, FRANCE, 1930.

Questions on lectures (choice of one subject). *(10 points)*
1st subject—Law of refraction.
2nd subject—The optical structure and accommodation of the eye.
3rd subject—Astronomical telescope.

Required Problem. *(10 points)*

A current passes through a galvanometer G, then divides into two branches which again unite farther on. The first branch contains an unknown resistance R, the other a galvanometer G' which is exactly like G'. The resistance of each galvanometer is 200 ohms and the deflections are proportional to the intensities of the current through them. It is observed that the deflection of G' is one-sixth that of G. Compute the value of the resistance R.

BOTANY-ZOOLOGY EXAMINATION.

Courtesy of Franklin R. Myers, Bernards High School, Bernardsville, N. J.

This examination was given as a term test covering two units of work. It consists of: (*a*) 10 multiple choice statements (Unit III, 1-10); and (*b*) 10 True-false statements (Unit III, 11-20); (*c*) 4 essay questions (Units I and II); (*d*) a diagram identification sheet; (*e*) a laboratory test of seed-dispersal methods; (*f*) and lantern slide identification. (Parts *d*, *e*, and *f* are not published at this time.)

UNIT I.

1. What does the fact mean to you that scientists find the fossil remains of the more simply developed animals such as sponges in the deeper layers of rock, while more highly developed kinds such as birds and mammals are found in the upper layers of rock?
2. Write a paragraph as you might tell some friend, on how seeds are formed in plants. Make it a complete story so he won't need to ask questions.
3. Tell as fully as you can how you think the knowledge and facts about plants and animals of which we learn in biology were found out.
4. Give as much as you can of the life history of the Ferns, telling how they reproduce, their characteristics and their structure.

UNIT II.

1. (*a*) Where do Fungi live? (*b*) What are their characteristics? (*c*) How are they important to us? (*d*) How do they reproduce themselves?
2. (*a*) What does "protos" mean? (*b*) What does "plasma" mean? (*c*) What is protoplasm? (*d*) Where do you find this substance, and what can it do?
3. Tell as completely as you can the following story: "Fertilization in Fowers."
4. (*a*) For what are scientists always seeking? (*b*) How do you think they have discovered the facts of which we learn in biology?

UNIT III. CLASSIFICATION OF PLANTS AND ANIMALS.

Underline the true statement or statements.

1. A phylum is: a genus—the name of the grasshopper family—a branch of the animal kingdom.
2. Bacteria belong to the: Pteridophytes—Spermatophytes—Lichens—Algae—Thallophytes.
3. In sorting plants, scientists would put in one group all those having: yellow petals—green stems—5 ovules in the ovary—a height of 5 feet.
4. A technical name for a plant or animal is made up of: one name—two names—three names.
5. Pond scum is in the class of: Algae, Fungi, Lichens—Mosses.
6. An ostrich belongs to the branch of the animal kingdom called the: Reptiles, Fishes, Mammals, Birds.
7. Melanoplus is the genus name—species name—of the red-legged grasshopper.
8. The wing of a bat resembles in structure our hand with its four fingers and thumb. This is an example of: homology—analogy.
9. The simplest animal of the following is: a bacterium—a sponge—a paramecium.
10. The plant phylum possessing a stem and leaf but no real root is: the Pteriodophytes—Bryophytes—Thallophytes—Spermatophytes.

Place a "T" or an "F" for "true" or "false" after the following statements as the case may be.

11. An alga contains the green substance chlorophyll.
12. A lichen does not have a green color.
13. A plant reproducing by spores is said to reproduce itself sexually.
14. Fungi are parasites.
15. A jelly fish is free to move about in search of food, but a sponge is attached to the bottom of the ocean. Therefore the sponge is considered higher in the scale of life.
16. A hookworm belongs to the Phylum of Roundworms.
17. The tapeworm enters the body through the soles of the feet.
18. Starfish may be found in Lindabury Lake.
19. A spider is an Arthropod.
20. A snail is a Crustacean.

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564. Comment on What Shall We Do This Year?

Vance D. Brown, Oil City, Pa., asked:

Has SCHOOL SCIENCE AND MATHEMATICS ever attempted to publish or collect a list of suitable science films for the various science subjects?

Answer by G. W. Warner, Editor of SCHOOL SCIENCE AND MATHEMATICS:

The answer is the job is too big. We could list the new films as

they come out as we list new books if we had some way of examining them and judging of their worth, but a list of all the good educational science films now on the market would leave room for nothing else in a publication like SCHOOL SCIENCE AND MATHEMATICS. Such a list was submitted to us a short time ago, but we had to reject it for lack of space. Film companies, the *Educational Screen* or the Society for Visual Education may be able to furnish such lists just as the book or apparatus companies put out catalogs.

An Answer.

574. *Miss Agnes M. Duggan asked for* "any literature or any material whatever on the development of the steam engine."

Answer by Mr. G. O. Ward, Technical Librarian, Cleveland Public Library, Cleveland, Ohio:

This is in reference to your inquiry concerning material on the history of the steam engine suitable for high school students.

Books devoted exclusively to this subject which are suitable for high school needs are wanting. Useful chapters exist in such works as Floyd L. Darrow's "Boy's own book of great inventions" (New York, Macmillan, $2), and Waldemar Kaempffert's "Popular history of American invention" (New York, Scribner, 2 volumes, $10). The former should be useful in any high school library. The latter, while much more expensive, is well written and well illustrated, so as to make it desirable where it can be afforded.

A book which contains historical along with other matter is W. F. Decker's "Story of the engine from lever to Liberty Motor" (New York, Scribner, $2.50). It is well adapted to the comprehension of high school students and should interest teachers of physics who are looking for material in the field of mechanics aside from history.

A good chapter on modern steam engines is found in Edward Cressy's "Discoveries and inventions of the twentieth century" (London, Routledge, 12 shillings, 6 pence; New York, Dutton, $5). This is somewhat less popular in character than Darrow or Kaempffert. Finally one must not overlook the useful historical matter in the general articles on the steam engine to be found in the various encyclopedias, particularly the Britannica and the Americana.

Trusting that this information will be found satisfactory, I am

Yours very truly,

G. O. WARD, *Technical Librarian.*

BOOKS RECEIVED.

First Principles of Chemistry by Raymond B. Brownlee, Stuyvesant High School; William J. Hancock, Erasmus Hall High School; Robert W. Fuller, Stuyvesant High School; Michael D. Sohon, Morris High School, and Jesse E. Whitsit, De Witt Clinton High School, all of New York City. Cloth. Pages vii+777+24. 12.5x18.5 cm. 1931. Allyn and Bacon, 2231 South Park Way, Chicago, Illinois.

Laboratory Exercises to Accompany The Brownlee-Fuller-Hancock-Sohn-Whitsit Chemistry. Revised Loose-Leaf Edition. Pages ix+282. 20.5x26.5 cm. 1931. Allyn and Bacon, 2231 South Park Way, Chicago, Illinois.

Workbook in Chemistry by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University, New York, and Ruth Maude Johnson, Newtown High School, New York City. Paper. Pages x+306. 20.5x26.5 cm. 1931. Allyn and Bacon 2231 South Park Way, Chicago, Illinois.

Plane Geometry by Frank M. Morgan, Director of Clark School (College Preparatory) Hanover, New Hampshire; John A. Foberg, Head of the Department of Mathematics, State Teachers College, California, Pennsylvania; W. E. Breckenridge, Head of the Depart-

ment of Mathematics, Stuyvesant High School, New York City; Under the Editorship of John Wesley Young, Professor of Mathematics, Dartmouth College. Cloth. Pages x+436. 12.5x19 cm. 1931. Houghton Mifflin Company, 2 Park Street, Boston. Price $1.40.

Directed Study Work Book for General Science, by Russell E. Bridges, Assistant Principal, Highlands High School, Fort Thomas, Kentucky and William C. Lee, Head of Department of Physical Science, Kentucky Wesleyan College, Winchester, Kentucky. Paper. 21.5x28 cm. 1930. Rand McNally and Company, Chicago. Part one, units 1 to 11 with tests for each and one general test. Part two, units 12 to 18 with tests for each and one general test.

Algebra For Today, Second Course by William Betz, Vice-Principal of the East High School and Specialist in Mathematics for the Public Schools of Rochester, New York. Cloth. Pages x+502. 12.5x19 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price $1.36.

Problems in Teaching Secondary-School Mathematics by Ernst R. Breslich, Associate Professor of the Teaching of Mathematics, The School of Education, The University of Chicago. Cloth. Pages vii+348. 15x22 cm. 1931. The University of Chicago Press, Chicago, Illinois. Price $3.00.

Essentials of Biology by W. H. D. Meier, Head of the Department of Biology, State Normal School, Framingham, Massachusetts, and Lois Meier, Instructor of Natural Science, State Teachers College, Trenton, New Jersey. Cloth. Price vii+529. 12.5x19.5 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston. Price $1.68.

Exercises in Arithmetic for Practice and Testing for Grade 4 by David Eugene Smith, Teachers College, Columbia University; William David Reeve, Teachers College, Columbia University; Edward Longworth Morss, Editor of Mathematical Textbooks. Paper. 100 pages. 16.5x23 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price 28 cents.

Exercises in Arithmetic for Practice and Testing for Grade 5 by David Eugene Smith, Teachers College, Columbia University; William David Reeve, Teachers College, Columbia University; Edward Longworth Morss, Editor of Mathematical Textbooks. Paper. 100 pages. 16.5x23 cm. 1931. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price 28 cents.

Plane Geometry Work Book (Books I and II) by Theodore Herberg, Chairman of Mathematics Department, Pittsfield High School, Pittsfield, Massachusetts and Sinclair J. Wilson, Chairman of Mathematics Department, Franklin K. Lane High School, Brooklyn, New York. Paper. 208 pages. 16x19.5 cm. 1931. D. C. Heath and Company, Boston, Massachusetts. Price 52 cents.

College Zoology by Robert W. Hegner, Professor of Protozoology in the School of Hygiene and Public Health of the Johns Hopkins University. Third Edition. Cloth. Pages xxiii+713. 14x21.5 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price $3.50.

Laboratory Guide for College Zoology by Robert W. Hegner, Professor of Protozoology in The Johns Hopkins University, School of Hygiene and Public Health. Cloth. Pages viii+75. 14x21.5 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price $1.00.

The Macmillan Table Slide Rule by J. P. Ballantine, Associate Professor of Mathematics, University of Washington. Paper. 4 pages, a square root slide, division slide and two multiplication slides also there are plates 1 for multiplication, L for powers, S for sines, and T for tangents. 22x28 cm. 1931. The Macmillan Company, 60 Fifth Avenue, New York. Price 50 cents.

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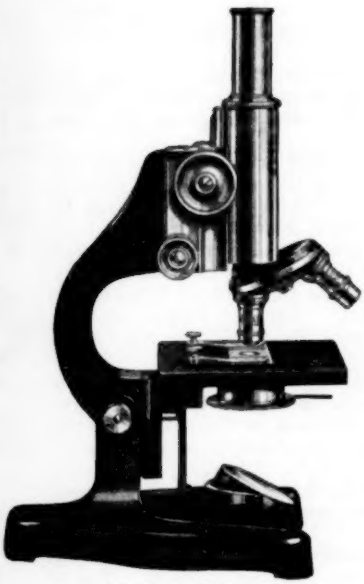

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The Mathematical Part of Elementary Statistics, A Textbook for College Students by Burton Howard Camp, Professor of Mathematics, Wesleyan University. Cloth. Pages xxi+409. 13x19.5 cm. 1931. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $3.60.

Wiedefeld-Walther Geography Test by M. Theresa Wiedefeld, Supervisor of Elementary Schools, Maryland State Department of Education and E. Curt Walther, Head of Department of Geography, State Normal School, Towson, Maryland. For Grades 4 to 8. Form A and Form B have 12 pages. 6.4x10 cm. A manual of Directions, a key for scoring and a class record are included in each package. Sold in packages of 25 at $1.15. World Book Company, Yonkers-on-Hudson, New York.

This Mechanical World, An Introduction to Popular Physics by Morton Mott-Smith. Illustrated by Emil Kosa, Jr. Cloth. Pages xvi+233. 12.5x19 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.00.

Plane and Solid Geometry by Joseph P. McCormack, Head of the Department of Mathematics in the Theodore Roosevelt High School, New York City. Cloth. Pages xii+541. 12.5x19 cm. 1931. D. Appleton and Company, 35 West 32nd Street, New York.

Qualitative Chemical Analysis, From the Standpoint of the Laws of Equilibrium and the Ionization theory by Louis J. Curtman, Associate Professor of Chemistry in charge of the Division of Qualitative Analysis, The City College of New York. Cloth. Pages x+539. 14x21.5 cm. 1931. Macmillan Company, 60 Fifth Avenue, New York. Price $4.00.

Quantitative Chemical Analysis, An Introductory Course by Henry P. Talbot, late Professor of Inorganic Chemistry at the Massachusetts Institute of Technology. Seventh Edition revised and rewritten by L. F. Hamilton, Associate Professor of Analytical Chemistry, Massachusetts Institute of Technology and S. G. Simpson, Instructor in Chemistry, Massachusetts Institute of Technology. Cloth. Pages xii+253. 14x21.5 cm. 1931. Macmillan Company, 60 Fifth Avenue, New York. Price $2.50.

Introductory College Chemistry by Harry N. Holmes, Professor of Chemistry in Oberlin College. Revised Edition. Cloth. Pages viii+550. 14x21.5 cm. 1931. Macmillan Company, 60 Fifth Avenue, New York. Price $3.25.

School Experiments in Electricity, Using the Special Transformer which can be built up of Various Interchangeable Components. Collected by E. Roller, Engineer and H. Pricks, Technical School Director. Translated into English by S. J. Davies. Paper. 86 pages. 14x21 cm. 1930. Published by Physikalische Werkstätten Aktiengesellschaft, Göttingen.

PAMPHLETS RECEIVED.

Two Modified Methods of Administering Two Standardized Group Intelligence Tests by C. C. Ross, Professor of Educational Psychology and Paul D. Gard, Assistant, Bureau of School Service. Bulletin of The Bureau of School Service, College of Education, Volume II, Number 4, 1930. 115 pages. 15x23 cm. University of Kentucky, Lexington, Kentucky.

Alcohol, Hygiene and The Public Schools, Digest of State Laws. Pages iv+44. 13x20 cm. 1931. Published by The Division of Research and Public Information Bureau of Prohibition. United States Government Printing Office, Washington.

Memorial and Peace Day, May 30, 1931. Circular No. 251. Compiled by L. L. Blair and Issued by Francis G. Blair, Superintendent of Public Instruction. Printed by authority of the State of Illinois. 48 pages. 15x23 cm. Schnepp and Barnes, Printers, Springfield, Illinois.

Calendar Improvement Without Legislation by Charles Clayton Wylie. Prepared at the Request of the University Association for the Study of Calendar Reform. 14 pages. 15.5x23.5 cm. 1931. The Athens Press, Iowa City, Iowa.

The Determination of the Graphic Forms and the Frequencies of the Forms Employed in the Current Reading Matter of the Non-Specialist. A Thesis in Education Presented to the Faculty of the Graduate School in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy by Walter H. Magil. 61 pages, 13 plates including maps, mechanical drawings, graphs, architectural drawings, electric circuit diagrams, and tables of data. 1930. University of Pennsylvania, Philadelphia, Pa.

Apparatus and Instruments for Physikal Instructions and Research. 96 pages. 20.5x29.5 cm. 1928-29. Physikalische Werkstätten A.-G., Göttingen (Germany).

BOOK REVIEWS.

"Work Book in Chemistry," by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University and Ruth Maude Jonson, Newtown High School, New York City. First edition. Pages x+306. 22x27x1.5 cm. Illustrated with 42 figures. Stiff paper cover. 1931. Allyn & Bacon.

This work book was built with the conscious purpose of applying to the teaching of chemistry some of the more important conclusions of competent psychologists who have been working in the field of experimental education. The psychology of learning, in general, is applied to the learning process in the special science of chemistry.

The book is not intended to displace either the text or the laboratory manual but to supplement both. The subject matter dealt with and the order of treatment are drawn from eight leading textbooks of high school chemistry and references to these texts are listed in a table in the forepart of the book.

The method of the book consists largely in the furnishing of multitudes of incomplete statements. Thus the pupil becomes aware that he lacks answers to many significant questions in chemistry. If he is at all a student he will be dissatisfied until he has found the answers to the questions. The book thus provides self tests for the pupil. There is much of excellent instructional guidance also in the book. This is especially true of those parts that deal with numerical calculations. The gas law corrections, for example, are splendidly handled. Much space is given to the more difficult parts of the subject. A reading of some of the exercises which deal with modern physical chemistry shows up to date treatment blended with decent conservatism. Ionization, ionic equilibrium, the completion of reactions, hydrolysis are among the topics glanced over by the reviewer and they were admirably handled. The treatment of atomic and molecular weights and formulas is also excellent.

Pupils who have this work book and who apply themselves to the task of satisfying its requirements are certain to learn a lot more chemistry than most of them would or could do without its guidance. Teachers should be sure to have a look at it. Frank B. Wade.

First Principles of Chemistry by Brownlee, Fuller, Hancock, Sohon and Whitsit. First edition. Pages vii+767+appendix of 24 pages. 14x19.5x3.5 cm. Many illustrations. Cloth. 1931. Allyn & Bacon.

So marked have been the changes and additions that this new text by the authors of Elementary Principles of Chemistry may truly be called a first edition. While retaining the many excellent features of the older book the authors have added many new and valuable improvements. The new illustrations are numerous and well chosen. The electronic theory is taught early and made use of thereafter.

"Learning exercises" are furnished at intervals in each chapter so that the student is helped to sum up and consolidate the material covered up to those points. Four general Tests are supplied each covering a certain section of the book. The new type questions are employed true-false, multiple choice and completion and in addition problems requiring simple calculation are provided.

The treatment of the metals instead of being categorical is by groups presenting interesting comparisons and emphasizing common principles. A reading of some of the chapters covering the newer theories shows that they are perhaps as up to date as is justifiable for elementary students. High school teachers of chemistry should see this text. F. B. Wade.

Elementary Algebra by Clinton A. Bergstresser, Head of the Department of Mathematics, Jamaica High School, New York City, and Elmer Schuyler, Head of the Department of Mathematics, Bay Ridge High School, New York City.

In the development of this text-book the authors have employed a number of "natural aids in learning and teaching algebra." Among the more outstanding of these natural aids are the introduction of the pupil to important algebraic concepts by the use of arithmetical numbers, the expression of numbers and quantities as different concepts, the treatment of ratios and rates as fractions, varied use of formulas, progressive treatment of graphs, the use of many natural self-directing measures and checks and, the stressing of functional thinking throughout the text.

The authors wisely have omitted some very common ambiguous terms, such as combine, collect, cancel, remove parentheses, and transpose. Explanations and instructions are direct and quite explicit making the book almost self-teaching.

The book is unusual in the large number of well graded exercises and problems. Statement problems are grouped and explained according to type. A large per cent of the applied problems are practical and closely related to the experiences of the modern school pupil. Wide use is made of exercises illustrating geometric figures and principles. Although the book is not an attempt at a text in general mathematics, the correlation of arithmetic, algebra and geometry is extensive throughout it.

In the introductory chapter are treated numbers, quantities, evalution of numerical and literal expressions, computation of formulas, and very simple linear equations. In the second chapter "Signed numbers" are introduced and illustrated in the usual manner by such means as thermometry, direction and gain or loss. The chapter entitled "Algebraic Expressions" includes the four fundamental operations, special products, and factoring, as applied to integral expressions. Other chapters in their order are "Fractional Expressions," "Graphs and Variables," "Equations of Degree One," "Radical Expressions," and "Equations of Degree Two." A short chapter on Trigonometry treats of the meaning and use of the simple trigonometric functions in right triangles. The book ends with a valuable series of "Cumulative Reviews."

The book should go far toward the accomplishment of the authors' purpose "to direct pupils in acquiring clear understanding, exact knowledge, ready skill, and real interest in the essential topics of elementary algebra, through the formation of useful habits of thought speech, and action." Walton A. Smith.

Arithmetic Activities, by R. G. Jones, Superintendent of Schools, Cleveland, Ohio, and H M Buckley, Assistant Superintendent of Schools, Cleveland, Ohio. Pages 213. Paper Bound. 13.5x18.5x1.7 cm. 1931. Division of Publication, Cleveland Board of Education, Cleveland, Ohio.

The material of this book was tried and adjusted by teachers, over

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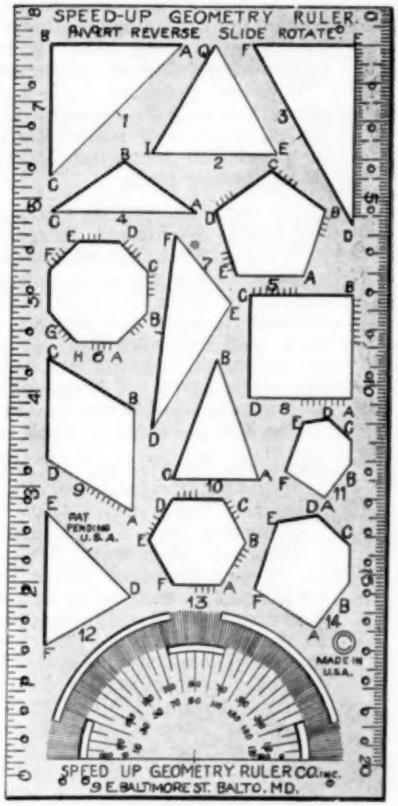

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a period of two years in a Cleveland school, organized to test methods of teaching arithmetic. It contains in an orderly and organized fashion only that material deemed suitable and desirable for children of the following types, Borderline, Kindergarten, and grades 1B to 6A inclusive, and covers a variety of topics taken from everyday life, household, and business transactions, that may be treated as Units. The children actually carry out the activities involved such as "Selling milk to classmates, weighing pupils, conducting bazaars, recording attendance, supervising school banking, scoring school games, and many other practical activities, have been used as a means of developing mathematical skill."

It is an excellent book for regular or supplementary work and should not be overlooked by the wide-awake elementary school teacher interested in new materials, processes and methods. The book may be purchased from the Cleveland Board of Education for the sum of eighty-five cents. Joseph J. Urbancek.

Geometric Concepts, by Clara H. Mueller, Cass Technical High School, Detroit, Michigan. Pages xi+205. 13x18.5x1.8 cm. 1931. John Wiley & Sons, Inc., New York. Chapman & Hall, London.

This book is designed to acquaint and familiarize pupils with geometric forms and their characteristics. The author has 87 well planned lessons, 190 figures, and 34 exercises, from which children may gain desirable knowledge of geometric concepts. Directions of procedure run throughout the text and formal proof has been omitted. The items of discussion involve the various phases of solids and are handled from an intuitive and psychological point of view.

The list price of the book is $1.60. Joseph J. Urbancek.

Magnetic Phenomena, An Elementary Treatise by Samuel Robinson Williams, Professor of Physics, Amherst College First Edition. Cloth. Pages xxii+230. 14.5x23 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price, $3.00.

Magnetic Phenomena is another volume of the International Series in Physics prepared under the general direction of Professor F. K. Richtmyer as consulting editor. It gives a view of the entire field of investigation of magnetic phenomena from the earliest discoveries to the present time. The chapter headings give a good indication of the subject matter discussed. They are I Magneto-Magnetics, II Magneto-mechanics, III Magneto-acoustics, IV Magneto-electrics, V Magneto-thermics, VI Magneto-optics, VII Cosmical Magnetism, VIII Magnetic Theories and Experimental Facts.

The author has presented this subject matter in an interesting manner and has pointed out the many unsolved problems of magnetism waiting the research student. Many references are given to assist students in surveying what others have done. This is a real inspiration for further study and original investigation. On every phase of the subject one is impressed with the care used in giving credit where it is due, and in pointing out the value of the study of magnetic phenomena to applied science on the one hand and to pure science on the other. The book is well adapted for class instruction and will certainly stimulate further research in magnetism. It is an unusually good book and congratulations are due to both the author and the publishers. G. W. W.

Experiments in Atomic Science for the Amateur by James L. Clifford. Illustrated. Cloth. 118 pages. 12.5x20 cm. 1930. Richard G. Badger, The Gorham Press, Boston, Mass. Price, $1.50.

This little book is a valuable contribution to the popular science library. It is a combined textbook and laboratory manual on the elementary ideas of radio activity and atomic structure. The author tells in language that can be understood by the average boy or girl what is known about atomic science and gives briefly the theories

advanced. The apparatus used in his experiments is largely home made and can readily be assembled in the ordinary school laboratory. Ingenious students will find many suggestions out of the regular channels for physics club demonstrations or for individual project work. G. W. W.

Burton Holmes Travel Stories, "China" by Eunice Tietjens. Cloth. Pages vii+408. 13x19 cm. 1930. Wheeler Publishing Company, 2831-33-35 South Park Way, Chicago, Illinois. Price, $1.28.

Here is an excellent supplementary reader for elementary school pupils. It tells all about the customs, manners, industries, buildings, products, amusements, schools and arts of the Chinese. It is beautifully illustrated, carefully edited, and attractive in every detail—a present for your little friend that will bring hours of delightful entertainment and a vast wealth of knowledge of a distant land and a strange (to Americans) people. This book is worth many times its cost. G. W. W.

Instructional Tests and Chapter Tests for a First Course in Algebra by Leonard D. Haertter, Head of the Department of Mathematics, John Burroughs School, St. Louis, Mo. Pages iv+159. John C. Winston Company, Chicago.

This book may be used for the purpose of testing pupil progress throughout a unit of work and at the end of the unit. The tests may be used with any first year course in algebra. They are comprehensive and if properly used should reveal individual weaknesses and thus provide intelligent bases for further instruction.

The tests are not too lengthy and yet they cover the essential abilities, skills and processes to be mastered by the pupil. Each page is pleasing in appearance as the material is not crowded, and there is ample space for computation. The reviewer feels that the book can also be used as a workbook and should find favor with teachers who desire supplementary exercises in their algebra work.

C. A. Stone.

Science Discovery Book by George C. Wood, Chairman of the Department of Biology and General Science, James Monroe High School, New York and Harry A. Carpenter, Specialist in Science, Rochester, New York Allyn and Bacon, Chicago. 1930.

There are three Science Discovery Books to accompany the three textbooks series, "Our Environment" by the same author. These books present space for recording the results of experiments and demonstrations and for the answers to many questions asked in the textbooks. There is also provision for directed study, for reviews and thought questions. There are self-testing exercises for each unit. Parts of the tests are composed of true-false questions. Multiple-choice and matching tests are also included. The books are well illustrated with pictures and diagrams, many of which are made the basis for further study.

The books are bound with a loose-leaf arrangement making it possible for the pupils to arrange the material in any desired order. Extra pages are added for pictures and clippings to be supplied by the pupils. These Science Discovery Books are very complete and supply more material than pupils could use. However there is a wide range of material making it possible for the teachers to select what they need. I. C. D.

Dietetics for High Schools by Florence Willard, Chairman of the Department of Home Economics, Washington Irving High School, New York, and Lucy H. Gillett, Supt. of the Nutrition Bureau, New York. Pages xxv+290. Macmillan. 1930.

Dietetics for High Schools has been written to help arouse in High School boys and girls an appreciation of the advantage of forming

correct food and health habits. The relation of vitamins and mineral elements to growth and health in the early years is especially emphasized. Many of the new discoveries are included in this textbook. Some of the Chapter headings are, "Energy Value of Foods," "Composition of Foods," "Mineral Elements," "Vitamins," "Food Selection," "Feeding the Family," "Food for the Baby," "Food for Children," "Marketing and Methods of Buying."

The book contains many valuable diagrams as graphs and tables. The book is written in an easy and simple style. Many questions and problems are included. This book presents the subject of dietetics in a complete and modern method. I. C. D.

A Survey of National Trends in Biology, by Edward J. v. K. Menge, Director of the Department of Animal Biology in Marquette University, Milwaukee, Wisconsin. xi+156 pages. The Bruce Publishing Company, Milwaukee, Wisconsin.

The book comprises a series of five lectures prepared by the author for the National University of Cordoba (Argentine) and for the Sociedade de Medicina e Cirurgia do Rio de Janeiro (Brazil). The central theme of the lectures is the modern progress of biology. Great care was taken to give in the discussions an accurate cross-section of the biological thought of the principal countries of the world in the present generation. An extensive bibliography covering twenty-one pages of fine print is given. This will prove a wonderful guide to sources for the use of any person making investigations along the line of progress in science. The book will prove valuable as a brief outline of biological problems and present-day tendencies in biological thought. Jerome Isenbarger.

Biological Foundations of Education, by Otis W. Caldwell, Professor of Education and Director, Institute of School Experimentation Teachers College, Columbia University; Charles Edward Skinner, Professor of Education, New York University; and J. Winfield Tietz, DeWitt Clinton High School, New York City. vii+534 pages. 116 figures. Ginn and Company, 1931.

The book is intended primarily, it seems, for reference and general reading, rather than for use as a text. Yet it is written in text-book form so that it is suitable to be used as supplementary to lecture courses or texts in education. This feature makes the book useful as a reference in any type of course in education. The book is not a general biology text, neither is it a treatise in education. It emphasizes those biological principles which are especially necessary to an understanding of animal behavior including man. The book is built on a new plan and it will meet a standing need in supplying specific practical biological material to go along with or follow a good course in general biology or in certain cases it will furnish a certain biological background for those who have not found it possible to get an extensive biological training. It furnishes desirable information which is fundamental but which writers of psychology and sociology texts have not been able to include. The authors are to be complimented on the production of this most useful new book.
Jerome Isenbarger.

Plane Trigonometry and Logarithms, by Thomas Marshall Simpson, Ph. D., Head of the Department of Mathematics, University of Florida. Pages viii+174+xvi+111. 12.5x18.5 cm. 1930. The John C. Winston Company, 1006 Arch St., Philadelphia. Price, $1.52.

The contents of this book are indicated by the following chapter headings:

I Graphs, Functions, Angles in Standard Position; II The Six Trigonometric Functions of an Angle; III Common Logarithms; IV Right Triangles; V Graphs of the Trigonometric Functions; VI

Oblique Triangles; VII Identities; VIII The Addition Formulas; IX Products and Sums of Sines and Cosines; X Solution of Oblique Triangles with the Aid of Logarithms; XI Inverse Functions and Trigonometric Equations.

The general angle and the general definitions of the trigonometric functions are introduced in Chapter I. The chapter on graphs of trigonometric functions is especially good. Emphasis is placed upon the reading of the graph as a tool. There are 11 illustrations and 122 figures. In the back of the book we find a sample test of modern type for each of the first eight chapters. The book has an attractive appearance. J. M. Kinney.

Introduction to Higher Geometry, by William C Graustein, Associate Professor of Mathematics, Harvard University. Pages xv+486. 13.5x21.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price, $4.50.

This book is designed to furnish the student with an adequate background for a study of Higher Geometry. It presupposes a knowledge of elementary analytic metric geometry and the elements of the calculus. It confines itself to an intensive study of the geometries associated with the projective group and the group of circular transformations. The treatment is both synthetic and analytic. The latter, however, predominates. The first eight chapters are largely introductory. They deal with such fundamental ideas as elements at infinity, homogeneous coordinates, line coordinates, cross-ratio, transformations, and complex elements. Chapters IX to XVII cover the projective geometry of the plane including affine and metric geometry. Chapters XVIII and XIX deal with the circle and space geometry, respectively.

The book is written in a pleasing style and presents an attractive appearance. J. M. Kinney.

Mathematical Tables and Formulas compiled by Robert D. Carmichael and Edwin R. Smith. Cloth. Pages vii+269. 15x23 cm. 1931. Ginn and Company, 15 Ashburton Place, Boston. Price, $2.00.

This book is divided into three parts. Part I gives the usual tables as follows: I. Common Logarithms; II. Important Constants; III. Logarithmic Trigonometric Functions; IV. Logarithmic Sines and Tangents of Small Angles; V. Natural Trigonometric Functions for Angles which are multiples of 15°; VI. Natural Trigonometric Functions; VII. Four-Place Logarithms; VIII. Four-Place Antilogarithms; IX. Four-Place Logarithmic Trigonometric Functions; X. Four-Place Natural Trigonometric Functions; XI. Logarithmic Trigonometric Functions of Angles expressed in Radian Measure; XII. Table for changing from Sexagesimal to Circular Measure of Angles; XIII. Natural Trigonometric Functions of Angles expressed in Radian Measure; XIVA Table for changing from Circular to Sexagesimal Measure of Angles. XIVB Minutes in Decimals of a Degree.

Part II contains the following tables: XV. Powers, Roots, and Reciprocals; XVI. Natural Logarithms; XVII. Exponential and Hyperbolic Functions; XVIII. Multiples of M and 1/M; XIX. Ten-Place Logarithms of Prime Numbers.

Part III contains formulas and graphs for reference as follows: I. Formulas and Theorems from Algebra; II. Theorems and Formulas from Elementary Geometry; III. Formulas from Trigonometry; IV. Formulas and Theorem from Analytic Geometry; V. Formulas and Theorems from Calculus; VI. Graphs for Reference; VII. Table of Integrals; VIII. Infinite Series.

On account of the excellent typography the tables can be read easily. Students in mathematics courses will find this an excellent book for reference. J. M. Kinney.

College Algebra, by Lloyd L. Smail, Professor of Mathematics. Lehigh University. Pages xv+450. 15.5x21 cm. 1931. McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York. Price, $2.50.

The function concept dominates the classification, arrangement, and treatment of nearly all of the material found in this book. This is indicated by the following chapter headings:

I Introduction; II Variables and Functions; III Linear Functions of one Variable; IV Quadratic Functions of one Variable; V Linear Functions of several Variables; VI Quadratic Functions of several Variables; VII Polynomial Functions of one Variable; VIII Fractional Functions of one Variable; IX Irrational Functions of one Variable; X Power Functions and Exponential Functions of one Variable; XI Logarithmic Functions.

Chapter XII treats such miscellaneous topics as Permutations and Combinations, Probability, Mathematical Induction, Binomial Theorem for any exponent. Chapter XIII consists of seventy pages of supplementary exercises. In the appendix we find an outline of a systematic logical theory of the number system of algebra and a summary of formulas of elementary algebra. There are nine tables as follows: Common Logarithms; Natural Logarithms: Trigonometric Functions; Powers, Roots, and Reciprocals; Compound-Amount; Present Value; Amount of an Annuity; Present Value of an Annuity; and American Experience Table of Mortality. J. M. Kinney.

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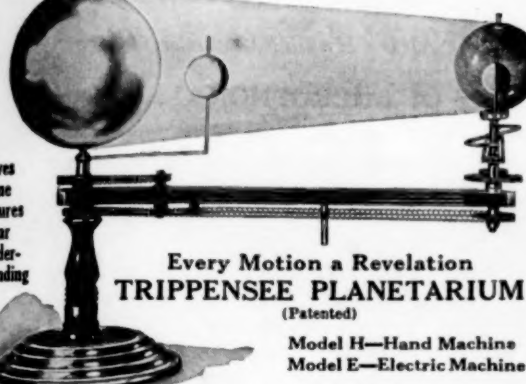

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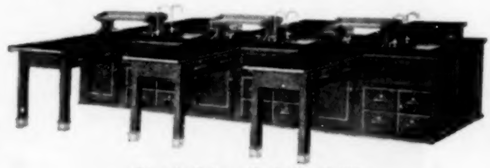

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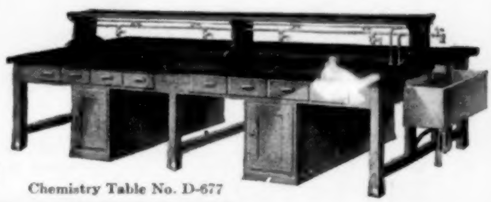

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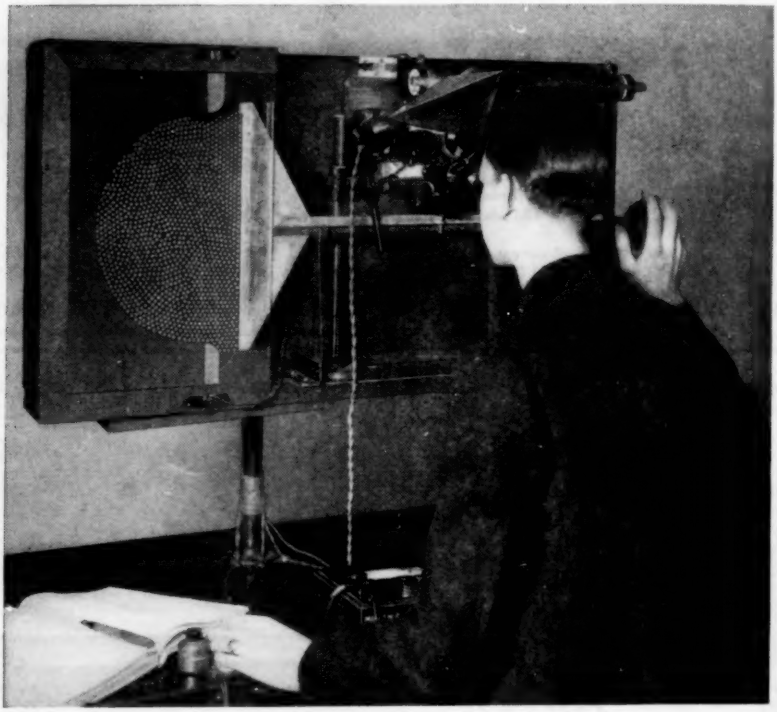
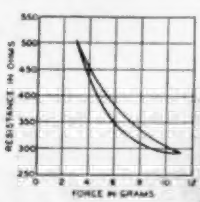
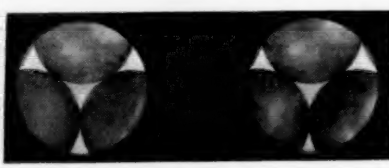
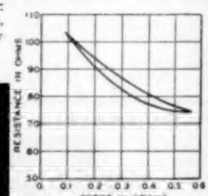


Above: The large-scale transmitter model. Below: Enlarged photographs of graphite-coated rubber balls, showing (on the right) increased contact areas under greater force



Force-resistance characteristic, large-scale model





Force-resistance characteristic, standard transmitter

Studies of microphonic action are facilitated in Bell Telephone Laboratories by a large-scale model of a telephone transmitter with the carbon granules represented by rubber balls coated with graphite. Force-resistance curves from this model are strikingly similar to those from an actual transmitter. Since resistance changes in the large model can be explained only by elastic deformation with consequent changes in conducting areas, support is given to the hypothesis that the microphone operates in a similar manner.

Copies of this poster 10″ x 14″ may be obtained by College Physics Departments by writing to the Bell Telephone Laboratories, 463 West Street, New York City. The illustration not only shows how the transmitter works but suggests how a variable rheostat may be made out of graphite coated small rubber balls.